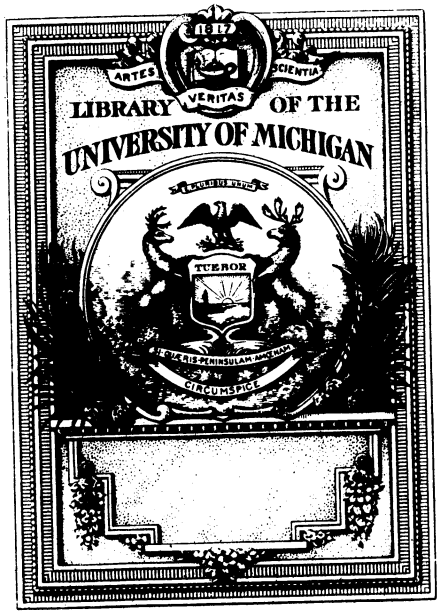

THE GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1921, 1922, AND 1923

ISSUED BY THE DIVISION OF GEOLOGY AND MINES
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THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1921, 1922, AND 1923

INTRODUCTION

By VICTORIANO ELICAÑO

In spite of the numerous setbacks which mining in the Philippines has suffered, and the great handicaps with which those engaged in mining have had to contend, the industry has not lost its attraction to local or to outside capital, and during the last three years a revival of activities has been observed in all the known mining districts. Gold production continues to be the barometer of mining activities, and most of the development is directed to the winning of this metal. Mountain Province still leads in production and, in spite of the shutdown of the Colorado Mining Company mines in Masbate, the total output of gold since 1921 has been on the increase. With the beginning of dredging operations by the Lianga Mines, Limited, at Lianga, Surigao, in 1922, a new district was opened up.

Next to gold, the most important Philippine mineral product is coal. Notwithstanding the drop in price in the local market, production has continued to increase, although no new district has been opened up. However, unless mining operations become more conservative and more systematic in a great many of the mines, it is feared that production of coal will soon lag. At present the total output is scarcely 10 per cent of the total consumption of coal in the Philippines.

Raw cement materials at Naga, Cebu, which were studied and favorably reported upon by the Bureau of Science in 1914, are now being utilized in the production of cement on a commercial basis at the plant erected by the Cebu Portland Cement Company. The enterprise has been a decided benefit to the country; first, because it has given a cash value to one of the available natural resources; and, second, because it has given the people the advantage of a lower price for cement in the local market. The local manufacture of cement has also made possible the development of gypsum prospects at Lobo, Batangas. The Philippine Gypsum Mining Corporation, owner of the deposits,

has been engaged in the production of sufficient gypsum to supply the needs of the cement plant.

During the last three years considerable interest was shown in the development of petroleum lands. Extensive geological explorations were undertaken by the Richmond Petroleum Company, the Union Oil Company, and the Banisilan Oil Company. The Richmond Petroleum Company started exploratory drilling in Bondoc Peninsula, Tayabas Province.

Intensive sugar-cane cultivation has created a larger demand for fertilizers, which encouraged the establishment of local factories. This new industrial activity opened up a new field for mining; namely, the search for and production of phosphate rock. The development of the local supply of fertilizers, like the local manufacture of cement, has also had beneficial effects.

This slow but continued progress of the mining industry does not mean, however, that under existing circumstances it can continue indefinitely. After more than twenty years of struggle under existing laws it is felt that the industry deserves certain relief, and to secure beneficial changes in the form of amendments in the laws affecting the industry the following amendatory acts have been recommended by His Excellency, the Governor-General, in his message to the Legislature:

1. An act amending the mining laws proper so as to permit the annual assessment work corresponding to a group of contiguous claims held in common to be concentrated on one or more claims of the group.

2. An act amending the corporation laws so as to permit members of a corporation engaged in mining to become also members of another mining organization.

3. An act amending the Administrative Code so as to do away with the direct tax on the product of mines.

4. An act amending the Philippine Tariff Act of 1909 so as to exempt certain articles from wharfage charge and to place on the free list certain imported articles used in mining.

A lengthy comment on these proposed amendments has been presented in a pamphlet on "Needs of the Mining Industry," prepared by Frank B. Ingersoll, president of the Philippine Chamber of Mines and Oil, and issued by that organization in April, 1923. The amendments have been fully discussed by both mining men and Government officials directly concerned or affected by the proposed legislation and have been exhaustively discussed in the Council of State before the final recommendation of the Governor-General to the Legislature. It is hoped that

the Legislature will soon see the dire needs of the industry and adopt measures which will put it on a basis that will insure its healthy development in the future.

In order to promote the further development of local industries the Bureau of Science has established industrial fellowships. These were initiated in 1921, and out of nine fellowships approved in 1922 six were connected with mining and geological work. The general plan followed is that the Bureau of Science furnish the technical employee and the other contracting party supply the necessary funds for the prosecution of the work. This type of coöperative work has been advantageous to both the Government and the mining industry since it enabled both contracting parties to carry on mining and geological investigation at a minimum of expense.

Such were the most important activities in the mining industry during the last three years. The resignation on September 3, 1922, of Dr. Warren D. Smith as chief of the Division of Mines and the absence of the writer from Manila as delegate to the second Pan-Pacific Science Congress in Australia greatly delayed the compilation of data for this publication. This issue is made to cover the activities of the last three years, but it is hoped that hereafter the publication will come out biennially as formerly.

The Division of Geology and Mines acknowledges its indebtedness and expresses its gratitude to the mining companies, private individuals, and Government officials whose coöperation has greatly aided the publication of this bulletin.

STATISTICS OF PRODUCTION

By RAMON F. ABARQUEZ

In the accompanying table are given the best figures available for Philippine mineral production in 1921, 1922, and 1923. The figures for 1921 were compiled by Mr. V. Elicaño, assistant director of the Bureau of Science and chief of the Division of Geology and Mines, and those for 1922 and 1923 were tabulated by the writer. The data were supplied in letters and reports from various sources. In securing the necessary figures the hearty coöperation of the provincial treasurers, the district engineers of the Bureau of Public Works, the various corporations, mining companies, and individuals deserves special mention. The provincial treasurers were responsible for most of the data concerning clay products, phosphate rock, lime, building and ornamental stone, and salt. The district engineers furnished the data for sand, gravel, and crushed rock; and the mining companies and individuals gave the figures for gold and silver, gypsum, asphalt and related bitumens, and iron castings.

While there has been a ready response from all quarters, still there are many provinces which failed to send reports; in fact, of forty-eight provinces only twenty-nine filed complete reports. Where no report is available an estimate based on previous reports has been generally resorted to. The tendency on the part of some of the operators to refrain from reporting their true production is not only a barrier to reliable statistics, but is also detrimental to the mining industry. In addition, some reports do not represent actual figures of production, for the method used in gathering the data is known to be unreliable. Nonadherence to uniform units has made recalculation necessary before the data could be tabulated. Better coöperation in the compilation of mineral statistics is strongly urged in order that the Division of Geology and Mines may best serve the mining public.

The total value of the mineral products of the Philippine Islands in 1921 was 6,158,851 pesos; in 1922, 5,742,721 pesos; and in 1923, 6,706,083 pesos. The decline in 1922 can be attributed to decreased unit price for most products.

TABLE 1.—*Mineral products of the Philippine Islands for 1921, 1922, and 1923.*

Product.	1921		1922		1923	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*[a]		*Pesos.*[a]		*Pesos.*[a]
Cast iron ..... metric tons	174	39,225	156	30,611	269	49,276
Silver [b] ..... fine grams	814,621	33,614	836,047	35,950	1,174,976	49,400
Gold [c] ..... do	1,976,096	2,626,192	2,205,857	2,932,092	2,537,162	3,372,654
Crude platinum ..... grams			42	179	420	1,791
Total value of metallic		2,699,031		2,998,832		3,473,121
Nonmetallic:						
Asphalt and related bitumens ..... metric tons	766	11,290				
Cement ..... barrels					37,557	255,387
Clay products [d], [e]		264,011		149,798		142,859
Coal ..... tons of 1,016 kilograms	39,445	808,626	41,752	856,345	42,762	874,441
Gypsum ..... metric tons					402	8,040
Lime [e] ..... do	3,558	150,127	2,553	61,230	3,224	97,044
Mineral waters ..... liters sold	639,513	170,406	558,200	142,356	474,033	113,796
Phosphate rock ..... metric tons			2,050	40,007	3,781	80,557
Sand, gravel and crushed rock [e] ..... cubic meters	526,137	1,081,000	418,238	797,827	398,222	722,135
Stone, building and ornamental [e] ..... do	48,972	173,674	57,097	91,049	50,550	102,838
Salt [e] ..... metric tons	31,247	800,686	69,345	605,277	76,194	835,865
Total value of nonmetallic		3,459,820		2,743,889		3,232,962
Grand total		6,158,851		5,742,721		6,706,083

[a] One peso Philippine currency equals 100 centavos, normally equals 50 cents United States currency.
[b] No silver is mined separately, but a small amount is alloyed with the gold.
[c] Value, 1.32923 pesos per gram.
[d] Includes pottery, brick, and tile.
[e] Estimate based upon incomplete data.

GOLD, SILVER, AND PLATINUM

By VICTORIANO ELICAÑO

GENERAL REMARKS

Of the metallic minerals of the Philippines, gold is first in importance, and its production can be taken as a barometer of the activity of the whole mining industry, since most operations of the industry are restricted to gold mining. Silver and platinum are by-products of gold mining, as these metals are not mined separately. Silver is usually found alloyed, with the gold in greater or less quantity, whether the yellow metal is obtained from lode or from placer operations. Native silver and silver minerals are known to occur in the Philippines, but no large deposits of this metal have as yet been discovered.

According to the reports of the Bureau of Customs the estimated values of gold and silver exported from the Philippines during the last three years are as follows:

TABLE 1.

Year.	Bullion.	Slag.	Total.
	Pesos.	*Pesos.*	*Pesos.*
1921	2,610,292	51,083	2,661,375
1922	2,867,912	32,945	2,900,857
1923	3,307,677	55,533	3,363,210

Of these amounts, 16,000 pesos worth of bullion was exported to Hongkong, China, in 1921; 30,045 pesos, in 1922; and 40,882 pesos, in 1923. The rest of the exports went to the United States.

The values of gold and silver production reported to the Bureau of Science during the past three years are as follows:

TABLE 2.

	Pesos.
1921	2,659,806
1922	2,968,042
1923	3,422,054

The difference between the figures from the customs exports and those turned in by the operators to the Bureau of Science

is due in part to the fact that a portion of the product is sold to local jewelers and merchants and so remains in the Islands. The amount mined is probably larger than that reported by the Bureau of Science, as some of the small and intermittent operators did not favor us with complete data; reliable estimates of the amounts produced from desultory mining cannot be had. Such operations are carried on in practically every known mining district.

For the first time in Philippine mining platinum was produced. Although recovered only in small amounts the production nevertheless is a good indication of what may be expected. The amount of crude platinum recovered was 42 grams in 1922, and 419.8 grams in 1923. A sample of the first recovery was submitted to the Bureau of Science for analysis; it contained 68.2 per cent of metallic platinum. The values given in our statistics are based on the world prices of platinum.

GOLD AND SILVER MINING

Practically all gold and silver production comes from the operations of three cyanide mills and three dredges. The mills are located in the Mountain Province and Masbate districts, and the dredges are operated in Camarines and Surigao districts. The geology and the ore deposits of these four districts, as well as accounts of past developments and activities in various properties, have been dealt with in articles published in previous issues of the Mineral Resources, and also in the Philippine Journal of Science; the following summary account is given to cover the activities during the years 1921, 1922, and 1923.

MOUNTAIN PROVINCE DISTRICT

This district includes what were formerly known as the Baguio and the Suyoc mineral districts. The first is located near the City of Baguio and the second is about 65 kilometers north of Baguio. The prevailing rock in this district is andesite, and the veins are usually true fissure veins, with subordinate contact deposits between andesite and diorite and between andesite and sedimentaries. Quartz, calcite, and manganese characterize the vein material, although manganese is very subordinate in Suyoc. The gold occurs in the metallic state, and also associated with iron pyrites, with galena and silver, and sometimes insignificant amounts of copper. Some veins in Suyoc carry tellurides and also zinc. Considerable development has been carried on in this district, and at one time several mills

were in operation. At the present time the district leads in total production, although it has only one lone producer.

The Benguet Consolidated Mining Company.—The property of this company is situated in Antamok River, about 10 kilometers by road east of Baguio. The mill is of the all-sliming type crushing in cyanide solution. Ever since it started operations, in September, 1915, this company has continued to increase its production, until at present it is the largest producer in the Philippines. It has kept its progressive policy of expansion, having increased its holdings in mineral lands and also made extensive additions to its equipment.

The mine workings, according to Mr. J. S. Colbath, the acting manager, have been deepened to F level, 500 feet below the adit tunnel and the sinking of the shaft is being continued below this point. Work on level C has demonstrated that the ore bodies on that level are more extensive and higher in value than were those on the upper levels. A new body of ore has been found east of the old workings on level C. The values on D level are not as good as those on C, but the vein on E level is showing up well and is slightly better than on D level. The development on levels C and D were sufficiently favorable to justify a large increase in the capacity of the milling plant, and beginning in 1922 the plant has been remodeled and enlarged, and at present has a milling capacity of about 8,000 tons per month. A new 300-kilowatt hydroelectric unit was completed in 1923, and in 1924 a new oil engine was installed, having a capacity of 200 kilowatts.

The following additional data were obtained from the company's annual reports:

TABLE 3.

	1921	1922	1923
Ore treated ..... tons..	40,941	46,244	75,159
Gross value of gold and silver bullion produced ..... pesos..	1,201,994.10	1,740,194.27	2,279,530.22
Dividends paid ..... do..	50,000.00	250,000.00	750,000.00

The quantity of ore reserves at the end of 1923 amounted to 264,032 tons valued at 9,515,559 pesos. It is claimed that three-fourths of the ore reserves are positive ore.

Exploration carried on in the adjoining Fianza claim, which was under option to the company, failed to disclose ore bodies of commercial value, so the option was given up. The company

has also taken an option on the Calvin Horr group, which is situated between the United States Army target range and the Acupan property. The ore showing on these claims, which was very good on the surface, is not proving satisfactory at depth. The development, however, is being continued by the company.

The Acupan Mining and Milling Co.—This company is continuing development work on its property in Acupan. The following notes have been furnished by Mr. T. Phillips, who is in charge of the work:

The Acupan Mining and Milling Co. Inc. controls 31 mineral claims, all adjoining and situated about 15 kilometers southeast of Baguio, on and near Batwaan Creek and within the jurisdiction of the Municipality of Itogon. The main development work has been done on a lode striking through the Gun and Big Gun claims in a north 70° east direction and dipping about 80° southerly. Approximately 5,000 feet of development work has been completed on this vein which averages about 5 feet in width, with an average gold content of about 18 pesos per ton. At a stockholders' meeting in 1923 it was decided to drive a low-level tunnel from a point near Batwaan Creek, which is about 205 feet lower than the lowest level, B. This new tunnel is known as level C and by actual survey its portal is 1,050 feet to the developed lode in B level. The work on C level was commenced in May, 1923, and 674 feet have already been driven.

Several other promising lodes have been opened up and assessment work has been done on other parts of this group of claims; but, for want of capital, no development work has been done on them.

In July, 1922, Dr. W. D. Smith, former chief of the Division of Mines, made a short examination of this property. Concerning its future Doctor Smith stated in his report:

* * * Therefore, from observations in the lowest workings the writer is very sanguine as to the prospects with depth. Not only does he expect that the vein will persist in depth but it is very likely to increase in width. One reason for this statement only will be given here, namely, the physiographic history of the region indicates that there have been considerable changes in the level of ground water and this is directly connected with the subject of secondary enrichment in the veins. From these facts which we can not discuss in detail here, we may expect an enrichment with depth in the ore bodies of this region.

It might also be pointed out here that there is quite as much showing on the surface where this vein outcrops in Batwaan Creek as could be seen in Antamok Creek at the time of the discovery of the present Benguet Consolidated lode. The writer's observations everywhere in the district in or near the diorite areas have been that conditions invariably improve with depth.

The Ukab Mining Co.—This company has been organized recently to carry out further development on a group of seven

claims which were owned by Mr. P. J. O'Neill. This group is situated near the Itogon Road and joins the Bua patented claims on the southwest. Development has been on a large lode with quartz-calcite with manganese, which according to reports assays high in free gold. The company will soon erect a mill for small-scale production and at the same time to help the development of the property. Amalgamation alone will be used for the present.

Headwaters mine.—This is situated north of the Benguet Consolidated property. It has had a very checkered history, much of which has not been beneficial to the mine. The activities of the last three years consisted mostly in development work. At present everything is idle, pending certain litigation about the property.

Petkell and Ullman groups.—These two groups, consisting of three claims each, are situated about 16 kilometers north of Baguio and about 1 kilometer from the Mountain Trail. According to Mr. J. S. Gillies there are eight veins in the Petkell group and four in the Ullman. These veins carry considerable manganese at the outcrops. The gold is free and surface samples showed high assays. These two groups have been worked in the past by Igorots, and it is reported that considerable gold has been mined from them. The present developments were started to tap the veins below the old Igorot workings.

The Palidan Slide.—This property is located in Suyoc, about 103 kilometers north of Baguio and 1 kilometer from the Mountain Trail. Except for intermittent desultory operations by the Igorots, there has been very little activity on this property. The former workings are now buried under about 80 meters of débris washed down from the sides of the valley. It is reported that negotiations with the Igorot owners are being carried on by a few mining men, and if successful a revival of activity is expected.

The Dugong group.—This group of five claims is located near the Palidan Slide. The property has been leased to Mr. C. F. Starkey, who since 1921 has been doing development work on the claims. There are three veins on the property, two of which carry free-milling gold, and the other contains considerable tellurides. The telluride vein varies from 2 to 4 feet in width, the other two are only about 2 feet wide. As far as present development reveals the veins contain valuable ore. This is proved by

the fact that Mr. J. S. Gillies, the principal owner of the group, in years past has taken out considerable gold by primitive Igorot methods. The claims are favorably situated, being near one of the Abra River tributaries which could be utilized for development of power.

The Pettit Brothers group.—This group consists of three claims owned by the Pettit brothers and Mr. W. Miller. The property adjoins the Dugong group, and like the latter contains three veins also. The gold is free milling but some is associated with pyrites. A drift on one of the veins has been driven to approximately 150 meters, and from this drift several crosscuts have been run to the adjoining veins. Only recently a plant consisting of a primitive arrastre, driven by water power and followed by amalgamating plates was installed. The plate tailings will later be concentrated in a table, since the pyrite has been reported to assay as high as 20,000 pesos per ton.

CAMARINES DISTRICT

This district comprises the properties in the neighborhood of Mambulao and Paracale in Camarines Norte Province. The district is well known for its past production, having been at one time the most important mining region in the Islands, both for its lode and for its placer mines. The ores are of the usual quartz type containing pyrite as the chief sulphide. Some copper is generally present and also rather frequently galena, sphalerite, chalcopyrite, pyrrhotite, magnetite, and their various oxidized derivatives. Manganese and arsenic are not frequent, and tellurides have been identified only in Tumbaga. The quartz is generally hard and massive, but becomes cellular with oxidation of the sulphides. The placer grounds in this district are nearing exhaustion, and mining activities are being directed toward the development of lode properties. Little or no new prospecting has been done, however; the present lode developments consist in reopening old workings.

Philippine Dredges, Limited.—This company is practically the only producer in the Camarines district. It is operating two dredges in Paracale River. One dredge worked from January, 1921, to August, 1922, redredging old ground during the whole time. This dredge is called Dredge No. 2. In August, 1922, a second dredge, Dredge No. 4, which was closed down in 1919, resumed dredging in virgin ground. The following ad-

ditional notes have been kindly furnished by Mr. Wm. Telford, manager of the company:

Dredge No. 2.—Cubic yardage turned over by Dredge No. 2, dredging worked ground only, amounted to 712,361 in 1921; 147,437 in 1922; 11,844 in 1923; and 251,158 in 1924 (September); approximate value, 288,000 pesos.

From February, 1923, to May, 1924, this dredge was under repair or working through another company's property to reach our own, and yardage was not recorded, as no gold was taken out.

The ground worked by No. 2 varied from 30 to 45 feet in depth, a very large portion being over 35 feet. The gold-bearing gravel is 1 to 3 feet in depth and is covered by a heavy clay overburden, made up of different strata, varying in color and toughness. In many places this clay went right onto the bedrock, which is also all soft pipe clay and can be dredged easily. The best class of wash dirt found was a pure white gravel.

When dredging for the first time, the clay overburden is rushed through a narrow sluice box, with a heavy head of water, in order to dispose of it in the shortest time possible. When the wash dirt is reached it is switched into a much wider sluice fitted out with gold-saving materials; matting, riffles, etc.

Dredge No. 4.—Cubic yards turned over by Dredge No. 4, all in previously unworked ground, amounted to 182,351 in 1922 (August to December); 459,554 in 1923; and 370,503 in 1924 (September); approximate value, 290,500 pesos.

This dredge was laid up in 1919, the buckets, etc., having been almost worn out, owing to high cost and difficulty in obtaining repair parts. It was restarted in August, 1922, after having been repaired and put in order.

The ground worked by this dredge averages about 25 feet in depth. It has a specially heavy clay overburden, and the wash varies from a very few inches to 2 feet, the greater part being less than 15 inches. Bedrock is all very soft and easily lifted by the buckets.

The small percentage of gold-bearing gravel is fairly free and easy to wash. It varies in color but is principally white. In parts, the gravel is found mixed also with the clay. Cost covering the aggregate of the two dredges, about 20 centavos per cubic yard. This is a very high cost as compared with dredging in Australia or New Zealand, but conditions are altogether different, and these have been accentuated by the aftermath of very abnormal conditions, and are inevitable.

Longos Development Co.—This company has taken up the old Baluarte and adjoining claims and has started development of the lodes at a lower level. The properties are situated on the east bank of Paracale River opposite the town of the same name. Some 400 feet of development have already been done on an adit which is only about 8 feet above sea level. The ore is refractory, but assays show a high content of gold and silver.

Mr. Jumper, who is in charge of the works, states that the company plans to install a small pilot-mill in order to test the milling qualities of the ore and also to help in the development expenses.

Reed's property.—Mr. J. R. Reed has restaked the ground where the old Candelaria group on the Dinaanan ridge was located, which is about 3 kilometers southwest of Paracale and on the Malaguit River side. Much of the surface material has already been worked in the past, and Mr. Reed is sinking a shaft to test the ore in the lower parts.

Tumbaga mine.—This property has been reopened under the direction of Mr. George H. Le Duc and Mr. E. A. Heise. Some development in lower levels has been undertaken and there are now exposed a few very rich stringers carrying much free gold. Due to water, development is slow and expensive. A small concentrating plant will be installed to treat the ore that has already been blocked, and if economically feasible development will be carried farther down.

MASBATE DISTRICT

The activities in this district are in the neighborhood of the town of Aroroy, Masbate. This district was the leading producer in 1918. In 1922 the Colorado mine and mill closed down, leaving only two operating mines in the district, the Syndicate and the Panique. The latter started milling in 1923. Calcite, quartz, and manganese characterize the veins in this district.

Syndicate Mining Co.—The property of this company is located about 8 kilometers south of Aroroy and about 4 kilometers from the Rio Guinobatan landing. Concerning the mine the following notes have been furnished by Mr. T. Uewaki, mining engineer of the company:

> The Syndicate Mining Co. is working chiefly three claims on the central part of Kalakbao Hill reserving the other thirty-one valuable claims.
>
> The rocks covering the Syndicate area are almost entirely igneous, consisting chiefly of andesites, diorites, and pyroclastics in which numerous gold-bearing veins are found filling fissures. These veins are affected by many faults having nearly east and west or northwesterly courses.
>
> The country rock in the oxidized zone is much altered near the veins, producing a brown, claylike rock generally showing traces of its original porphyritic structure.

The highest point on the outcrop of Champion vein is 650 feet above the Guinobatan River level which is generally considered as the permanent water level in this district.

The veins are developed in six different levels, and the total length of tunnels exceeds 30,000 feet.

Among the twenty-one veins known, the principal ones that are being mined at present are listed below. They are all fissure veins with quartz, calcite, and manganese as vein filling.

TABLE 4.

Vein.	Width.	Length known.	Strike.	Dip.
	ft.	*ft.*		
Star No. 1	5	2,400	N 27° W	85° to SW
Star No. 2	4	350	N 30° W	60° to SW
Star No. 3	6	420	N 40° W	65° to SW
Bin Cross-Cut	10	1,700	N–S	70° to SW
Nancy No. 1	3 to 20	1,250	N 30° W	70° to SW
Nancy No. 2	15 to 65	5,000	N 45° W	75° to SW
89 Vein	3	350	N 45° W	83° to SW

The Star veins are composed of a very hard, dark blue quartz carrying irregular amounts of manganese and pyrite, the dark color being due to finely divided particles of manganese oxide.

The Bin Cross-Cut vein is of medium hard quartz, containing limonite mud and manganese oxide.

The Nancy No. 1 vein is composed of honeycomb quartz and manganese oxide forming a well-defined banded structure, and the hardness increases with depth; contains much calcite down below.

The Nancy No. 2 vein which is the biggest one in this district can be traced over 5,000 feet and the values, as a rule are found near both walls for a width of 10 to 35 feet. This vein is also composed of quartz, calcite, and manganese oxide, and the calcite content increases with depth.

The 89 vein which is a very narrow streak carrying extremely high values is composed of rather softer quartz with a little limonitic mud and manganese oxide and it contains no calcite.

The flow sheet of the mill has been described by Mr. J. O. Enberg, mill superintendent, as follows:

The ore is received from the mine by means of a gravity tram with 2¼-ton cars and by a mill level adit. The ore is delivered to a 65-ton storage bin. From this bin it is fed by gravity to a trommel washer with a 40-inch diameter by 16-foot mixing chamber running on tires and rollers and driven by a rope drive through miter gears and spur and pinion on washer at six revolutions per minute. The washer is lined with plain ½-inch curved iron plates and has two flights of spirals made of heavy angle iron to promote discharge of the ore. The trommel is slightly conical, the same size as washer, and 5 feet long. It is punched with ½-inch round tapered holes.

Water is introduced with the ore in the washer partly at the feed and partly as a high-pressure spray at the discharge to wash the ore thoroughly and free it of clay and slime. The fines discharge is led by a launder to a Dorr duplex classifier which is set to discharge practically all minus 200-mesh slimes. The sands from this classifier are dragged forward and discharged to the tube mills, entering the regular cyanide circuit. The slimes are led to a storage tank and fed to an 8-foot Senn Batea pan amalgamator running at 175 revolutions per minute with a §-inch motion. This feature is somewhat of an innovation and was made necessary by the fact that the ore contains an unusually high percentage of clay and slime that prevents it from settling in the thickeners. Before the Senn pan was tried the settling and filtering capacity was not nearly equal to the grinding capacity of the mill, the slime at times requiring over 20 square feet of settling area per ton as compared to about 7 feet for free settling slimes. Since the pan has been in operation, the settling and filtering capacity is equal to the grinding capacity and has shown an increase of 70 per cent. Extraction on the Senn pan is very low as would be expected due to the very fine state of the gold that passes over the classifier and to the fact that this gold is contained in all the clay and slime washed out of the total ore received. However, only about 10 per cent of the tonnage passes over the Senn and the heads are very low due to the extremely fine classification; so that the total loss per ton is low and is many times compensated for by the large increase in tonnage and the saving in cyanide and lime necessary per ton milled as well as an increased extraction in the cyanide circuit.

The washed oversize from the washer trommel goes by means of a 16-inch belt conveyor to a storage bin for the crushers, discharging on a 5-foot by 8-foot grizzly with ¾-inch spacings, the oversize going to the crusher bin and the undersize to the Ball mill bin. The coarse ore is fed to a 10-inch by 16-inch Blake type crusher set at 1½ inches and running at 230 revolutions per minute. The crusher product goes to a set of 16-inch by 36-inch D. E. W. Co. rolls set at ¾ inch, the product from the rolls going by means of a 14-inch belt-and-bucket elevator to the Ball mill storage bin. The elevator discharges onto a small grizzly with ½-inch spacings, and the undersize goes by a conveyor belt to a fines-storage bin from whence it is fed by a revolving disk feeder to the Abbe tube mill whenever the load of sand will permit.

From the Ball mill bin the ore is fed by means of a 30-inch revolving disk feeder to a 16-inch by 6-foot Hardinge Ball mill running at 25 revolutions per minute. Sufficient solution is introduced for dilution to about 30 per cent moisture. The Ball mill discharge, all of which is minus ¼-inch mesh, is elevated by means of Frenier sand pumps (10-inch by 54-inch) to two Dorr duplex classifiers, the slimes going to two 30-foot Dorr thickeners and the sands going to one 60-inch by 6-foot Hardinge pebble mill and one 6-foot by 16-foot Abbe tube mill. The discharge of these two mills is elevated by the Frenier pumps to the two Dorr classifiers, and the classifiers return the sands to the mills and the slimes to the thickeners.

From the thickeners the thickened pulp is conveyed by diaphragm pumps to three 30-foot Dorr type agitators placed in series. The pulp

from the final agitator goes to three Kelly type filters. The filters are loaded by a 6-inch Byron Jackson sand pump and the cake formed in from seven to ten minutes, by means of a montejue and an air compressor at 45 pounds pressure. After the cake is formed the excess pulp is returned to the agitator and barren solution is introduced into the filters from a storage tank through a 5-inch Goulds centrifugal pump at 35 pounds pressure for a period varying from thirty to sixty minutes and dependent on the tonnage being handled. After the barren wash, water is introduced and a wash of two to five minutes is made. The filters are then run out and the cake sluiced to waste. The filter cycle ordinarily takes two hours.

The total effluent solution from the filters is pumped by a low-speed centrifugal to No. 6 thickener and clarified by settling, thence it goes to the mill solution pump and is elevated by a 7 by 8-inch Goulds triplex pump to the mill solution tank. This solution is used in the grinding and classifier circuit.

The clear overflow from the thickeners goes to a 15-foot fiber clarifier, thence to a 15-foot sand clarifier, and thence to five six-compartment zinc boxes where the values are precipitated. The barren solution from the zinc boxes is elevated by a 7 by 8-inch Goulds triplex pump to a barren solution storage tank at the head of the mill whence it returns to the filters for the barren solution wash.

The zinc boxes are cleaned and dressed weekly and the resulting shorts and precipitates are roasted and dried respectively, and fluxed and smelted in a No. 275 "Case" tilting furnace.

Power is furnished by two 150-horsepower Mirrlees Diesel engines and one 165-horsepower Busch-Sulzer engine, all direct connected to direct-current generators generating current at 110 volts. Motors are used for all drives and the average power consumption at present, including one 35-horsepower air compressor for the mine, is 2,000 to 2,100 amperes.

Mr. W. G. Carpenter, general superintendent, has given the following additional data:

TABLE 5.

Year.	Production.		Development.	
	Ore milled.	Bullion produced.	Ore developed.	Cost of development per ton.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*
1921	60,438	756,323.22	72,200	1.20
1922	65,180	869,409.40	88,697	1.12
1923	68,376	799,923.48	72,536	1.14

We are still using the all-sliming process as in past years but as the grade of ore is falling an endeavor will be made to cheapen cost by the addition of leaching vats. We have also been experimenting with a surface deposit carrying about 5 pesos worth of gold per ton with a view to making it profitable. Indications point to our being able to leach this deposit by charging directly into tanks, and a 250-ton leaching tank with

the necesary solution tanks and equipment have been erected and operations will commence before December 1, 1924. For want of a better name we have called this surface deposit a "talus." It really is the float from a quartz vein above mixed with decomposed andesite which forms the bed rock.

Panique mines.—This property is being operated by the co-partnership of Schwab and Geringer. It is located south of the syndicate property on Paniqui River. The veins are regular fissure type averaging 4 feet in width and carrying a high percentage of free-milling gold. The ore is crushed through 20-mesh in stamps, the entire discharge passing over amalgam plates. The plate tailings are sent to a Dorr classifier. From the classifier the sand heads are run to vats and leached with cyanide solution, while the slime tails are thickened in order to save water and the slime is discharged to waste. The average value of the mill heads is 12 pesos per ton, about 50 per cent of which is extracted over the plates. The total chemical charge is about 1 peso per ton of ore. This includes cyanide, zinc, and lime. The lime is made from calcite taken from the mine and contains a sufficient amount of gold to pay for the burning. The present capacity of the mill is about 10,000 tons a year. The quantity of ore blocked at the end of 1923 is approximately 80,000 tons.

Colorado Mining Co.—Owing to depletion of ore reserves and to lowering of the grade of ore this company decided to stop operations in April, 1922. The company exploited a number of lodes on Bagadilla Mountain, of which No. 5, Sub-2, 8, and 9 are the most important. There are, in addition, a number of veins intersecting No. 5, which carry stringers of high-grade ore. The No. 5 vein has been the most important and has been opened for a length of 2,300 feet and to a depth of 800 feet. In many places it has had widths of 30 feet of pay ore. It has been reported, however, that besides the lowering of the grade of ore the veins seemed to be splitting with depth and, owing to this fact and the heavy flow of water, deeper prospecting was discouraged. The mine yielded a fair return upon the original investment and in general the enterprise may be considered successful.

Napuangan group.—This property, which in 1919 and 1920 produced over 60,000 pesos, is at present inactive. The Colorado Mining Company, it is understood, had an agreement for developing this mine, but owing to the liquidation of this company the Napuangan claims might either be thrown open to

public occupation or be developed by the present holders of the Napuangan.

Balete group.—Like the Napuangan, this mine is inactive. The Argus Mining Company still holds the property.

SURIGAO DISTRICT

Gold mining in this district began in very remote times. The metal, detected first in the sands of the rivers and beaches, was traced almost at once to its original home in quartz stringers and pockets in the andesite, which constitute the land mass of the region. Although small, these quartz bodies appear to have been rich in gold at the surface, and in many places the ore has been taken out from open trenches and shallow holes over considerable distances. The general character of the mineralization, the variety of rocks encountered, and the apparently nonuniform distribution of the gold values in this district are suggestive of conditions at the Tumbaga mine in Camarines district, where rich pockets of gold are found in calcite and quartz veinlets cutting andesite and indurated shale.

The Cansuran Mining Company began in this district the first hydraulicking operation practiced in the Philippines. It worked during 1914, but owing to the spotted character of the ground operations were discontinued. At present there is one dredge operating in the southern part of the district, the only producer on a large scale. However, by primitive methods, the natives obtain considerable gold from practically all the rivers flowing from the Diwata Mountains.

Lianga Mines, Limited.—This company owns twenty-two claims along Tambis River, a tributary of the Hinatuan. The company bought the Umeari dredge and started operations on the property in April, 1922. In November, 1923, the dredge was temporarily shut down for repairs and also to introduce innovations in the tables to overcome certain difficulties. Some of these difficulties are: Lightness of a considerable portion of the gold particles, resulting in failure to make good contact with mercury; the presence of a great quantity of black sand and some limonite particles which block the riffles and render them useless; and the presence of clay, which could not be disintegrated by the ordinary equipment, causing considerable losses of gold. A clay disintegrator is being installed to overcome the last-named difficulty.

The company produced about 2,422 ounces of gold bullion in 1922, and 1,421 ounces in 1923. In addition, it secured 42 grams of platinum concentrate in 1922, and 419.8 grams in 1923. The average dredging cost is 22 centavos per cubic yard.

Tinibingan mines.—Mr. W. B. Davey has reopened this property, which is located in Placer, and plans to do more development work.

OTHER DISTRICTS

Cebu, which has contributed most of the coal production of the Philippines, may also become one of the gold producers, if the plans of a group of mining men in that locality are successfully carried out. Several claims have been located along the course of Toledo River and it is reported that several test holes have been sunk with favorable indications. It is being planned by the claim holders to put in a dredge very soon.

A company is also being organized to develop some claims in San Marcelino, Zambales, and prospecting work has been carried on in Pangasinan, Mindoro, and Catanduanes.

COPPER, LEAD, AND ZINC

By ANTONIO D. ALVIR

COPPER

Though there has been no large production of copper in the Philippines within the last thirty years, still a good many native implements of copper have been produced locally by the Igorots in Mankayan, Mountain Province district. During the Spanish régime a considerable quantity of copper ore is known to have been taken out of the Mankayan-Suyoc copper deposits, and copper was produced in primitive smelters. Besides the Mankayan-Suyoc copper deposits, which are the most important, there are several other known deposits in Benguet, Pangasinan, Batangas, Mindoro, Marinduque, and Masbate Provinces, and in Panay and Mindanao Islands.

A. J. Eveland wrote a lengthy report on the Mankayan-Suyoc deposits.[1] Several Spanish publications regarding the district have also appeared, but they are now of only historical importance. Examination of these properties has been made from time to time, and a considerable quantity of 1 to 10 per cent copper ore has been revealed. The deposit is in the form of large irregular breccia veins, the cracks of which have been filled with minerals. Alteration and replacement of the wall rock, which is quartz porphyry, have also taken place. Dr. L. A. Faustino, assistant chief of the Division of Geology and Mines, has identified the following minerals from polished sections of specimens from this district: Quartz, kaolinite, pyrite, chalcopyrite, covellite, enargite, and luzonite.

The information here given on the development of the Mankayan copper deposit within the last three years was supplied by Mr. Phil. C. Whitaker. Development work on the old Mankayan properties has continued up to the present time, but practically no copper has been produced. Mr. V. E. Lednicky was in charge of the development work. Unfortunately, he

[1] A preliminary reconnaissance of the Mancayan-Suyoc mineral region, Lepanto, P. I., Bull. Mining Bureau No. 4 (1905).

left for the United States several months ago and, although he left records of what has been done, his own observations and opinions have not been recorded.

Two adits were driven at right angles to the vein. Adit No. 1 was driven 35 meters below the old Spanish drain tunnel for a distance of 80 meters in ore without reaching the wall rock. Some good ore was encountered here. Adit No. 2 was driven 38 meters below Adit No. 1 for a distance of 300 meters and some ore was encountered. A shaft is being sunk to connect the old Spanish drain tunnel with Adit No. 2 for the purpose of improving the air circulation. Contrary to previous belief, the development work has shown that the ore persists to a depth of at least 78 meters below the old Spanish workings, although nothing definite regarding the quantity is shown at the present time. Approximately 40,000 pesos have been expended since the beginning of 1921 on the various claims. An air compressor, and a pipe and Pelton wheel for generating power have been brought up to the mines.

LEAD AND ZINC

There has been no commercial production of lead or zinc in the history of mining in the Philippines. However, valuable deposits of these two metals are known, the most important of which occur in eastern Marinduque, halfway between Santa Cruz and Torrijos, and at Milagros, Masbate. The Marinduque deposits are owned by the Marinduque Mining Company, which did development work on fifteen claims from 1916 to 1920. During the last three years, however, nothing further has been done. The deposits are fissure veins in andesite varying in width from 4 to 10 feet. The ore minerals are galena and sphalerite embedded in a quartz gangue. Some rich pockets run as high as 60 per cent lead, some up to 45 per cent zinc, and other veins carry 2 to 3 per cent copper. However, the average run of the ore is lead, 6 per cent; zinc, 6 per cent. Some development work has been done by Mr. Schwab at Milagros, Masbate.

IRON AND STEEL METALS

By RAMON F. ABARQUEZ

TABLE 1.—*Philippine cast-iron production from 1907 to 1923.*

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Metric tons.	*Pesos.*		*Metric tons.*	*Pesos.*
1907	132	19,536	1916	93	18,864
1908	97	17,500	1917	66	17,936
1909	78	31,078	1918	70	24,983
1910	50	20,023	1919	67	34,964
1911	37	29,159	1920	87	40,191
1912	141	49,272	1921	174	39,225
1913	227	64,471	1922	156	30,611
1914	199	56,274	1923	269	49,276
1915	96	22,694			

INTRODUCTION

The iron industry of the Philippine Islands, which involves the manufacture of plowpoints (*sud-sud*) and plowshares (*lipia*), showed continued activity during 1921, 1922, and 1923. The output in 1923 was the largest since 1907, although the value was less than in 1913 and 1914.

Prices of iron castings had dropped far below normal, owing to the general business depression, an after-effect of the World War, that became acute in 1921. Prices at the central offices fell almost 50 per cent, and the low prices have continued until the present time. Although American-made products have been introduced and cheaper substitutes have been made by the Chinese from scrap iron, local production of iron castings (mostly agricultural implements) during the last three years has been gratifying. The continuously increasing demand indicates that the home-made product is preferred over others. As a matter of fact, the Angat castings have been proved by the farmers to be harder, more capable of high polish and, hence, more desirable than those made by the Chinese.

As a result of the increasing demand for rice greater attention is being directed to that industry. Mountain sides as well as hilly places have been converted into rice-growing regions. Through the recent enactment of a law by the Philippine Legislature giving better facilities to homesteaders, homestead conditions have been much improved. The Angat irrigation system, which is nearing completion, will make available

for rice cultivation vast areas of tillable lands which have for years remained unproductive. In the preparation of the field for rice culture the ground must be loosened or broken up every crop season with the aid of the plow. Philippine rice fields are peculiarly adapted to the use of native plowpoints and plowshares; simple as they are, they have been found better suited to Philippine topography than the larger machinery. Hence the demand for iron castings will be greater as the area devoted to rice cultivation increases.

IRON ORE

The important iron deposits known to date are in Bulacan, Camarines, and Surigao. The probable ore in Bulacan, according to an estimate made by the Bureau of Science, is over 1,000,000 tons; that in Camarines, over 1,000,000 tons; and that in Surigao, over 500,000,000 tons. Magnetite sand has been reported to exist in workable quantities along Manila Bay near Mariveles, Bataan Province.

The Bulacan deposits supply the ore used in the native furnaces, although no systematic development of the different properties has been followed. The ore consists essentially of magnetite and hematite, in intimate mixture but in varying proportions. Quartz is the predominant gangue mineral. Pyrite occurs in the ore in varying proportions. The magnetites are soft and a considerable portion (perhaps 20 per cent of the ore mined) is objectionably fine. About 405 tons of iron ore were mined in 1923; 234 tons, in 1922; and 261 tons, in 1921. These figures represent the amounts charged into the Angat furnaces.

The Camarines deposit, situated on the western part of Calambayanga Island, in Mambulao Bay, Camarines Norte Province, consists of almost pure hematite with traces of magnetite. The hematite is massive or granular, and the ore is moderately soft and very porous or vesicular. A small portion of pyrite in fresh crystals can be detected in the hematite, and quartz is found sparingly in scattered grains or in veinlets. The average ore carries about 60 per cent of iron and is free from undesirable constituents. The deposit has been worked by a Japanese concern. It was extensively worked for a time. However, only one shipment of the ore from this country to Japan had been made when adverse conditions made it necessary to suspend operations.

The Surigao ore is principally ferruginous clay, but contains also an abundance of small round pellets of hydrous iron

oxides. The average ore contains about 52 per cent of iron and is free from objectionable impurities, such as sulphur and phosphorus. The deposit has been reserved by the Government.

The Mariveles black sand is found concentrated along the beach and carries about 90 per cent of magnetite.

MINING AND SMELTING

Mining of the ore is still in an undeveloped state and consists mainly in breaking up boulders with hammers and iron bars or in scraping the ore out of the shallow pits by simple methods. The ore is mined and sorted at the pits and the material is carried in baskets to the smelters. The selected ore charged into furnaces usually carries more than 60 per cent of metallic iron. All quartz-bearing materials are eliminated, and those containing even a small amount of pyrites or chalcopyrites are also discarded as waste.

In 1923 sixteen furnaces were in operation, all in the Angat district: two are at Camaching; one at Montamorong; five at Tincugan; four at Pilon; two at Malinao; and two at Asana. Mining and smelting methods are similar in all of these places, and the materials used for the furnaces at the several mills vary but slightly. Where no deposit of good clay is available for furnace lining, as is the case in and around Camaching, imported refractory bricks have been used for the last three years. At other places, such as Montamorong, Tincugan, Pilon, Malinao, and Asana, where good refractory clay is within easy reach, no change has been introduced.

The organization of the Manila Iron and Steel Company brought about the erection in 1920 of a blast furnace with some modern improvements, in which it was intended to treat the black sand that abounds along the beach at Mariveles, Bataan. Operations had to be discontinued, due to failure to get the magnetite sand into such form as would make it suitable for charging into the furnace.

Matias Fernando, one of the present operators, intends to build a smelter in Angat. It has always been the practice to have the smelting done at places in the mountainous regions near the ore deposits and the charcoal supplies. With this transfer of the smelter to the more populous district greater transportation cost will be involved in getting the ore, fuel, and clay from the mountains. However, these disadvantages may be sufficiently offset by the elimination of the cost of feeding the laborers, an item of some importance in the industry; lowering of wages; and more efficient supervision of the work.

A similar move is being contemplated by Francisco de la Concha, who prefers the barrio of Sibul, San Miguel, for his plant site.

IMPORTATION OF IRON AND STEEL

The Philippine Islands imports many kinds of iron and steel. In 1921 imports amounted to 43,529,079 pesos; in 1922, to 15,208,761 pesos; and in 1923, to 17,392,001 pesos. Table 2, taken from the Annual Reports of the Collector of Customs, shows the quantity and value of the different steel products imported into the Philippine Islands during 1920, 1921, 1922, and 1923.

TABLE 2.—*Iron and steel imported into the Philippine Islands.*

Article.	1920		1921	
	Quantity.	Value.	Quantity.	Value.
	Kilos.	*Pesos.*	*Kilos.*	*Pesos.*
Pig iron	2,149,201	170,385	1,346,324	89,799
Bar iron	524,320	107,549	222,877	51,161
Bars or rods of steel	14,486,984	2,842,005	19,538,791	3,395,632
Railway track materials	22,451,041	3,196,580	14,284,320	2,800,371
Corrugated roofing	4,324,336	1,741,230	11,016,220	3,315,462
All other sheets and plates	3,787,421	1,108,485	5,937,949	1,724,685
Structural iron and steel	7,138,851	1,711,891	4,432,526	1,449,083
Wires and cables	2,733,667	1,315,499	3,843,303	1,549,150
Nails, spikes, and tacks	2,402,863	682,071	4,019,728	1,207,365
Needles, nuts, bolts, washers, and rivets	----------	532,443	----------	706,719
Pipes and fittings	4,387,395	1,602,384	5,216,827	1,919,541
Tools	----------	1,626,811	----------	1,738,268
All other manufactures	----------	27,472,474	----------	23,583,643
Total	----------	44,109,807	----------	43,529,079

Article.	1922		1923	
	Quantity.	Value.	Quantity.	Value.
	Kilos.	*Pesos.*	*Kilos.*	*Pesos.*
Pig iron	721,168	44,366	1,521,190	102,711
Bar iron	53,790	8,095	164,377	20,968
Bars or rods of steel	3,208,447	405,321	6,047,097	764,998
Railway track materials	3,447,485	329,309	8,478,187	947,447
Corrugated roofing	12,871,557	2,910,893	7,347,561	1,728,636
All other sheets and plates	3,647,165	941,341	7,823,814	1,693,114
Structural iron and steel	2,816,395	666,055	5,586,753	777,281
Wires and cables	2,172,819	450,424	3,141,214	693,911
Nails, spikes, and tacks	3,497,371	567,087	3,730,254	685,054
Needles, nuts, bolts, washers, and rivets	----------	234,156	----------	260,800
Pipes and fittings	2,493,483	656,397	3,643,406	794,316
Tools	----------	785,786	----------	755,168
All other manufactures	----------	7,209,531	----------	8,167,597
Total	----------	15,208,761	----------	17,392,001

FERRO-ALLOY METALS

Manganese.—Manganese oxide in nodules has been known to occur in Ilocos Norte in a shallow bed; its original location has been traced by Smith [1] to small stringers in a recent andesite flow. Manganese also occurs in small pockets in the quartz veins in the gold districts of Benguet, Masbate, and Camarines. An excellent grade of manganese ore has also been found in Pangasinan Province, but the deposit is limited in extent and is of little commercial value.

Chromium.—Chromite has been found in some of the Major Creek lodes, Benguet Subprovince, as small botryoidal masses, black with a sublustrous appearance. Another deposit has been found in Antique, associated with serpentine in heavy granular masses and with a mottled black and green appearance. A similar deposit has been discovered in Candelaria, Zambales.

Molybdenum.—A small amount of molybdenite has been found as steel-blue flakes in quartz veins, in the Mountain Province district and in Lobo Mountains, Batangas Province.

Tungsten.—Wolframite has been reported to occur in Antique Province, Panay, although its occurrence has not as yet been verified.

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[1] Asbestos and manganese deposits of Ilocos Norte, with notes on the geology of the region, Philip. Journ. Sci. § A 2 (1907) 145.

COAL

By LEOPOLDO A. FAUSTINO

TABLE 1.—*Philippine coal production and imports from 1917 to 1923.*

Year.	Production.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons of 1,016 kg.	*Pesos.*	*Tons of 1,016 kg.*	*Pesos.*
1917	5,658	141,425	397,152	3,076,470
1918	15,416	385,400	398,730	4,662,349
1919	32,374	822,300	394,229	7,781,307
1920	57,960	1,452,200	531,547	10,792,077
1921	39,445	808,626	454,614	6,987,002
1922	41,752	856,345	454,208	5,009,362
1923	42,762	874,441	457,956	4,997,302

INTRODUCTION

Coal mining continues to be one of the most important of the mineral industries, the value of the coal produced in 1923 being 874,441 pesos, or a little over 13 per cent of the total value of the mineral output for that year. With the exception of 1920, which represents the abnormal postwar production, the annual output of the coal mines during the last three years has never been exceeded since coal mining began. The total production for 1921, 1922, and 1923 is greater by 12,551 tons than for the four previous years, and exceeds by 73 tons the total coal production of the Philippines up to and including 1912. It will be remembered that in 1912 the coal-mining industry suffered a setback and that from 1913 to 1916 there was no commercial production. The present development of the industry began in 1917. The peak production of 1920 will probably not be exceeded for some years to come—certainly not until more development work is done on the producing mines and more attention is paid to promising properties in undeveloped districts.

The present production comes from the three principal coal fields: namely, Cebu; Batan Island, Albay; and Malangas, Min-

danao. Other known fields, such as Polillo and Sugud, Sorsogon, have not yet contributed their share to the total coal production and probably will not make any contribution for some years to come, or until the price of coal increases sufficiently to make mining in these fields commercially profitable. As the cost of transportation is an important item in the coal-mining industry, it is hoped that the problem may be partly solved with simultaneous development of two or three localities in one district or the discovery of new fields close to some means of easy communication with established railroads. In order that this idea may be given impetus, and for ready reference by those engaged in coal prospecting or the development of new and old fields, the following list of provinces known or reported to contain coal is given:

Abra.	Iloilo.	Occidental Negros.
Agusan.	Lanao.	Oriental Negros.
Albay.	La Union.	Rizal.
Bohol.	Leyte.	Samar.
Bulacan.	Masbate.	Sorsogon.
Cagayan.	Mindoro.	Surigao.
Camarines Sur.	Mountain.	Tayabas.
Capiz.	Nueva Ecija.	Zambales.
Cebu.	Nueva Vizcaya.	Zamboanga.
Davao.		

Agusan and Bohol are included in the above list, although the Division of Geology and Mines has only been shown samples supposed to have been taken from those provinces. No definite locality is given. Since Becker's report [1] it has become known that Leyte possesses coal. However, it was only recently that a sample from that locality was sent to the Bureau of Science for identification. This sample is said to have been found in Sitio Bagahupi, Barrio of Uban, Municipality of Babatngon.

The following provinces are not known to contain any coal, but careful search in some of them may reveal deposits of importance:

Antique.	Cotabato.	Palawan.
Bataan.	Ilocos Norte.	Pampanga.
Batanes.	Ilocos Sur.	Pangasinan.
Batangas.	Isabela.	Romblon.
Bukidnon.	Laguna.	Sulu.
Camarines Norte.	Marinduque.	Tarlac.
Cavite.	Misamis.	

[1] 21st Ann. Rept. U. S. G. S. pt. 3 (1901) 89.

Of the three coal fields (Cebu, Batan, and Malangas) Cebu has maintained the steadiest output and, with the exception of 1921, when Batan produced about 600 tons more, has led the other two districts in total production. In 1922 Batan was a poor third, but in 1923 that field showed signs of healthy development, and 1924 may find it competing for first place.

Cebu.—In 1921 Cebu had fourteen coal operators producing coal in greater or less quantities. Among these are included holders of coal revocable permits or the coal prospectors' license issued by the Bureau of Lands. These have small workings and use rather primitive methods of mining. They correspond to "wagon mines," "snowbirds," and "country banks" of the United States. In 1920, when coal prices were high, a large number of coal revocable permits were issued. They contributed then no small amount to the total production. In 1921 these small workings produced only about 11 per cent of the coal production of Cebu. The other 89 per cent came from the mines of the National Coal Company at Licos, the Danao Coal Mining Syndicate at Camansi, and the Uling-Naga Coal Company at Uling. In 1922 the small workings, or "paquiao," as they are oftentimes referred to, produced only 149 tons of the total 20,077 tons for the whole Cebu field. In 1923 the number of coal operators was reduced to five, and with one exception all workings under coal revocable permits closed down. Practically the whole production came from the mines of the National Coal Company, the Uling-Naga Coal Company, the Danao Coal Mining Syndicate, and the Cebu Coal Mines, Incorporated.

The bulk of the production of the National Coal Company at Licos came from its No. 8 slope, which has been driven approximately midway between the north and south boundaries of the property. It will be remembered that four seams have been recognized in this property; namely, the Carmen, the Esperanza, the Abella, and the Enriqueta. These are named from west to east; that is, from lowest to highest. All the seams strike in the same general direction, north 23° east, and dip about 40° to the southeast. A fifth seam, the Pilarica, recorded by Spanish engineers and supposed to lie about 40 meters east of the Enriqueta, has never been met. The No. 8 slope cuts the Esperanza and the Abella seams, but the main haulageway at the foot of the slope has been driven on the strike of the Abella seam. Crosscuts have been made to the Esperanza, the Carmen,

and the Enriqueta seams. From these crosscuts tunnels have been driven on the strike of the Esperanza and the Carmen. Crosscut No. 1 East, driven from the Abella to find the Enriqueta, struck a badly disturbed area and no recoverable coal, and the Enriqueta tunnel is at this writing in barren area. Crosscut No. 2 East from the Abella tunnel, driven about 350 meters from the foot of the slope, also failed to find the Enriqueta. Late in 1923 the main haulageway in the Abella struck the east and west fault, which is about 500 meters north of slope No. 8 and has been known since Spanish times as the general fault. After driving through 70 meters of rock the coal has been met again. The present plans of the National Coal Company are not known. Search for the Enriqueta seam has been stopped temporarily. The main haulageway continues on the Abella, and slopes are being driven to lower levels. It is intimated that diamond drilling may be resorted to in order to help locate the Enriqueta and to determine the exact nature of the other coal seams present in the area.

About 4 kilometers north of Mount Licos are the mines and workings of the Danao Coal Mining Syndicate at Camansi. This company changed hands in 1922, and the new owners have planned extensive development work. South of Danao River and near the present terminal of the tramway five seams are recognized. These seams have been known since Spanish times and, while they strike in the same general direction as the Licos seams (that is, north 20° east) and dip to the southeast, the two districts have never been correlated. From west to east these five seams are the Carmen, No. 3, No. 2, No. 5, and the San Luis. Mr. Florentino M. Canga, who has been connected with coal mining in Cebu since the early days of the Spanish Inspección General de Minas, ventures the opinion that the Camansi No. 2 can be correlated with the Licos Abella, No. 3 with the Esperanza, and Carmen with the Carmen. The basis of the tentative correlation is the presence of a fire clay floor in both of the Carmen seams, and the distance between No. 2 and No. 3 and between Abella and Esperanza, which is 14 meters. The roof of Esperanza contains fossils, and so does the roof of Camansi No. 2. A hurried examination of the fossils seems to point to the correctness of the correlation, but a detailed study of the stratigraphy of the district is necessary to arrive at any definite conclusion.

North of the tram terminal on the other side of Danao River four seams are known, all striking about north 60° west and

dipping to the northeast. From west to east these seams are the Santa Barbara, the Inday, the Casilda, and the Rosalia. A tunnel has been driven on the strike of the Santa Barbara, and a slope has been started to crosscut the Inday seam.

In the Mount Uling coal district the most important seam is the Doña Margarita seam. This seam has been known since the early days of Spanish occupation and has been the one most eagerly sought. It averages about 3 meters in total thickness. About 1860 a tunnel 647 meters long was driven to strike this seam, and according to the record of the Spanish inspectorate actually reached the large bed. In 1915 another tunnel was driven under the supervision of Wallace E. Pratt, formerly chief of the Division of Mines, and the coal was reached at a distance of 121 meters. A slope was then driven on the dip of the bed and carried to a distance of 98.4 meters, when the old Spanish workings were encountered. In 1920 during my first visit to Cebu I found a tunnel being driven at about the same elevation as the Spanish tunnel of 1860 but directed at right angles to the seam. This tunnel, which is now known as Doña Margarita Tunnel No. 1, has not yet reached the seam on account of several interruptions, but it is now being worked energetically.

There are at least four other seams on the eastern slope of Mount Uling, all dipping in the same general direction as the Doña Margarita seam; namely, 40° to 50° northwest. These seams, averaging about 50 centimeters in thickness and locally known as the coking coals, have been encountered in both the old and the new Doña Margarita tunnels. They have been traced for a distance of approximately 3,000 meters and were at one time the source of the greater part of the production of the holders of coal revocable permits. On the western side of Cebu Island near the town of Toledo on the slopes of Mount Uling are some coal seams which are probably the continuation of the seams that have been opened up on the eastern side of the mountain. Some prospecting has been done here with "paquiao" workings, producing small amounts of coal.

According to J. C. Nichols, who has done considerable prospecting and some development work, there are two commercial seams in this territory. One seam is from 50 to 75 centimeters in thickness while the other seam, which is from 5 to 8 meters below the first one, varies from 1 to 1.4 meters in thickness.

Batan.—During the last three years the main producers of this field were the Liguan Coal Mines, Incorporated, J. E. Barker,

Calanaga Coal Mining Company, Philippine Coal Mining Company, Albay-Gulf and Pacific Company, and A. U. Betts.

The Liguan Coal Mines, Incorporated, is operating at Liguan on the western end of Batan Island. The United States Army mine, opened up here in 1905, was not much of a success and all work was abandoned in 1910. In July, 1921, the military authorities turned the property over to the Civil Government, who leased it to E. C. Walters on December 15, 1921. N. T. Hashim succeeded E. C. Walters, and the Liguan Coal Mines, Incorporated, was formed to undertake the development of the property. Production began in 1922. At first scows were used in loading coal to ships but with the completion of a modern pier in June, 1922, interisland steamers coaling at Liguan have been able to load at the pier. Five seams are known here, but only four are contributing to the production. The seams are numbered from top to bottom; that is, the highest seam has been named No. 1 and the lowest No. 5. Geologic conditions are very complicated and there has been much faulting and close folding. The coal is of bituminous and subbituminous rank.

On eastern Batan several companies have operated. The Philippine Coal Mining Company produced during the first half of 1921 between 300 and 500 tons a day. About the latter part of 1921 the company went into the hands of receivers, and nothing has since been done on the property. The Albay-Gulf and Pacific Company did some development and produced some coal from the property to the west of the Philippine Coal Mining Company. At the present time A. U. Betts is operating near the barrio of Dapdap and he has driven three tunnels. As many as eight seams have been claimed for eastern Batan, but the greater bulk of the output has been produced from only three seams. The most important of these seams measures 1.7 meters in thickness. The coal beds at the extreme eastern end, which were worked by the Philippine Coal Mining Company, have a gentle dip, but those now being developed by Mr. Betts dip about 30°.

Near the center of the island there has been found the continuation of some of the seams that occur on the east and west ends of the island. J. E. Barker prospected and did some development work, and the Calanaga Coal Mining Company under his supervision produced a good amount of coal in 1923. At least two minable seams are known near Caracaran, and the coal is of bituminous rank.

Malangas.—This field is controlled wholly by the National Coal Company and comprises the workings at Gotas, Butong, Camp Wilmot, and other places.

The workings at Gotas consist of several adits, the most important of which are Adit No. 4, the Water Level, and those above Tunnel No. 14. A great deal of stripping by Subano Moros has been done. Part of the production has been done under contract, and the National Coal Company has directed its efforts to the Water Level tunnel, which has been driven so as to drain Adit No. 4. The coal seams in this area are slightly folded, and igneous intrusions have been encountered in several of the workings. The most important seam measures 1.3 to 1.8 meters in thickness. A great part of the production of the National Coal Company comes from the Gotas area.

The principal opening at Butong is a small shaft, which from present indications would seem to have been sunk at the top of a dome structure of the coal measures. This shaft was built in 1920 and all the main headings have been driven sloping away from the bottom of the shaft. The coal is semianthracite and measures as much as 3.1 meters in thickness. The workings have produced a fairly large amount of coal, but the output does not find a ready market on account of its unsuitability for local use.

The outcrop at Camp Wilmot was discovered about October, 1920. Development work consisted in sinking a small shaft. Some stripping has been done, and "paquiao" or contract work has contributed no small amount to the total production. Production from the Perez outcrop located at Kilometer Nine began in December, 1922, and has since continued consistently, although in small amounts. The Suico outcrop near Dumaguit has produced good coal, but transportation is slow and the production small.

The main transportation system of this coal district is a 12-kilometer railroad from Butong to tidewater of the port of Malangas on Dumanquilas Bay. A flat-topped ridge separates the Gotas field from Butong. The production from the Gotas workings is trammed by hand to the foot of an incline, where it is pulled to the top of the ridge by a hoisting engine. An aërial gravity tramway from the top of the ridge connects with the railroad cars at Butong. Production from "paquiao" or contract workings are hauled on sledges drawn by carabaos. At Malangas ships lie alongside the wharf and are loaded by means of a tipple. A coal bin has been built near the wharf.

PRODUCTION AND UNIT OF MEASUREMENT

Since Act 2719 became effective coal production has been compiled from figures submitted by the different coal operators. As may be seen from Table 1, production for 1923 is greater by 1,010 tons than in 1922, and by 3,317 tons than in 1921. The total coal production of 1923 is only exceeded by that of 1920, when abnormal postwar conditions prevailed. In spite of the seemingly increased production, the local output is still far below the amount consumed every year (see Table 1).

The unit of measurement used in this report is the ton of 1,016 kilograms. According to the laws relating to weights and measures the metric system is the official system in the Philippines, but Act 2719 provides taxation on the basis of the ton of 1,016 kilograms. Coal dealers in the Philippines use the ton of 1,016 kilograms, which is the gross, or long, ton (2,240 pounds). Unless the unit is otherwise expressly stated, the word ton as used in this report means the ton of 1,016 kilograms, to which all other figures reported have been reduced; this applies to the tables of imports and exports as well as to other figures.

TABLE 2.—*Coal imported into the Philippine Islands from 1919 to 1923, inclusive, by countries, in tons of 1,016 kilograms.*

Country.	1923		1922		1921		1920		1919	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
United States	8,340	130,107	8,081	117,476	14,921	403,939	14,547	162,029	1	20
Spain									383	9,860
Canada									1	32
China	33,240	295,513	32,915	232,983	25,465	350,116	61,671	1,039,113	38,976	518,477
Japanese China	139,460	1,577,152	70,236	727,491	37,260	241,779			15,878	150,757
British East Indies	9,775	173,057	5,305	71,250	10,997	175,318	34,197	737,613	20,641	354,929
Dutch East Indies					393	4,714	374	1,880	2	36
French East Indies	62,625	362,638	16,641	128,974			943	12,511	5,807	94,480
Japan	117,211	1,435,443	212,247	2,652,444	285,390	4,721,334	320,829	7,408,949	307,255	6,549,883
Australasia	87,305	1,023,392	108,783	1,078,244	80,188	1,089,802	98,986	1,429,982	5,285	102,833
Total	457,956	4,997,302	454,208	5,009,362	454,614	6,987,002	531,547	10,792,077	394,229	7,781,307

TABLE 3.—*Coke imported into the Philippine Islands from 1919 to 1923, inclusive, by countries, in tons of 1,016 kilograms.*

Country.	1923		1922		1921		1920		1919	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
United States			90	6,350	569	16,812	232	4,506	328	12,405
United Kingdom	15	350								
China	207	3,177	250	5,442	100	1,825	694	25,147	260	8,890
British East Indies			2	155	4	302	2	169		
Japan	76	2,266	57	1,744	26	920	32	1,149	486	18,083
Australia	661	22,164	752	22,241	772	28,626	968	29,261	121	3,117
Total	959	27,957	1,151	35,932	1,471	48,485	1,928	60,232	1,177	42,495

TABLE 4.—*Coal exported from the Philippine Islands from 1919 to 1923, inclusive, by countries, in tons of 1,016 kilograms.*

Country.	1923		1922		1921		1920		1919	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*	*Tons.*	*Pesos.*
Guam					0.2	[a]175				
British East Indies					1.6	[a]3,500				
Hongkong							250	6,000		
Australia			59	960						
Total			59	960	1.8	[a]3,675	250	6,000		

[a] These figures cannot be verified.

PETROLEUM AND RESIDUAL BITUMENS

By LEOPOLDO A. FAUSTINO

INTRODUCTION

Interest in the petroleum resources of the Philippines has continued unabated. With the passage of the Petroleum Leasing Act and the publication of the regulations of the Department of Agriculture and Natural Resources providing ways and means for acquiring tracts of land for prospecting and development, numerous companies and individuals have begun earnest search for favorable structures. All the localities known or reported to contain oil have received attention and one district at least has been prospected by drilling. Contrary to impressions which have gained considerable credence abroad, the Government of the Philippine Islands is trying its best to help promote the development of the petroleum industry. The petroleum laws enacted and the regulations promulgated have been made as liberal as is consistent with good sound policies. Apparently, the point of greatest objection is the short period of five years for which a lease may be had. It is desired to call attention to the provisions of law regarding this point, wherein it is specifically stated that renewals may be had until the maximum of fifty years is reached. The lease period of five years has been decided upon to meet local conditions and to save valuable oil land from falling into the hands of speculators. Companies and individuals who have acquired leases under the present laws will only need to show sufficient evidence that they have complied with the regulations, and that they want to hold the land for development and not for speculative purposes, in order to secure renewals of their leases. At the present writing petroleum in commercial quantities has not been found in any of the known Philippine localities, but it is hoped that, though gushers are not to be expected, small wells may be a reality in the not distant future. The following is a brief account of the petroleum development in the Philippine Islands during the last three years.

OIL FIELD DEVELOPMENT DURING 1921, 1922, AND 1923

Among the localities known or reported to contain oil, the following have been the subject of prospecting and development under the terms of the geological exploration leases:

South end of Bondoc Peninsula, Tayabas Province, southeastern Luzon.
Northwestern part of Leyte Island.
Southeastern part of Mindoro.
Pidatan district in central Mindanao.
Toledo, Cebu.
Rizal Province, in the vicinity of the town of Antipolo.

Bondoc Peninsula, Tayabas Province.—This district has been the scene of the most active prospecting and development. In a recent report[1] by Jorge B. Vargas, Director of Lands, the total area of petroleum leaseholds in the district on March 31, 1923, was placed at about 41,000 hectares. Several companies and individuals had geological exploration and drilling leases covering the more promising areas, but only two actually sank drill holes to prove their holdings. The other companies maintained a more or less "watchful-waiting" attitude, and gave up their leases one by one when the results of the drilling operations became generally known.

E. A. Heise and the Union Oil Company had several leases, but little or no development work was done by either. The Banisilan Oil Company filed application for the areas which were surrendered by the Union Oil Company, but terminated its lease on December 31, 1923, without attempting to drill. E. W. McDaniel operated in the Maglihi area. Several shallow wells have been drilled in this section, three of which have produced petroleum in small quantities by pumping. These wells have never been pumped for any length of time, partly on account of lack of storage facilities, and it is not known how much petroleum can be obtained by continuous pumping, or whether enough petroleum is accumulating at the bottom of the wells to keep the pumps busy. It is claimed, however, that Banco wells No. 3, No. 4, and No. 5, which were drilled in 1918 and 1919, would probably average about one barrel a day. The first well drilled in Bondoc Peninsula was Bahay well No. 1, in 1906. Drilling was done entirely by hand power and reached a depth of 127 feet, and a small quantity of gas and oil was obtained.

[1] Not published.

The Richmond Petroleum Company,[2] a subsidiary of the Standard Oil Company of California, started drilling operations in this district in the early part of 1921. Several test wells were sunk, the greatest depth having been reached in Piña Well No. 1, which was drilled to a depth of 5,117 feet. Other wells are Amuguis No. 1, drilled to a depth of 1,323 feet; Sapa No. 1, 3,757 feet; and Yebaan No. 1, 617 feet. According to reports on these wells the Richmond Petroleum Company has drilled at Bondoc Peninsula a total footage of 10,814. Slight indications of petroleum and natural gas have been encountered, but of oil nothing that even nearly approached commercial quantities was found under the structures tested. C. T. Newcomb, superintendent, Philippine district, Richmond Petroleum Company, has kindly donated to the Bureau of Science a sample of oil recovered from Piña well No. 1 at between 101 and 1,019 feet; this sample can be seen in the exhibit room of the Division of Geology and Mines. Other companies that applied for drilling leases in this district are the Lucena Oil Company, the Philippine Oil Company, the Columbia Oil Company, the Paco Oil Company, the Manila Oil and Pipe Association, and the American Oil Company. None of these commenced actual drilling and all surrendered their leases in 1923.

Another locality to receive attention from the Richmond Petroleum Company is northwest Leyte, where this company had leases in the municipalities of San Isidro, Calubian, and Villaba. Though considerable geologic work was done here by the company, prospecting by drilling was not resorted to and the leases were terminated. William Anderson leased certain tracts of land in the municipalities of Villaba and San Isidro, and also certain areas in the municipalities of Leyte, Palompon, and Ormoc, but little or no development work was done on the properties. The Banisilan Oil Company had leases on the area adjoining the areas leased to Mr. Anderson. Mr. Elicaño, chief of the Division of Geology and Mines, undertook the geologic exploration for the company under the terms of a Bureau of Science industrial fellowship. Favorable structures were located which would warrant exploratory work by drilling, but nothing has as yet

[2] This company discontinued drilling activities in July, 1924, and has stored all its field equipment at Manila pending the finding of other favorable geological structures in other parts of the Archipelago. It has also surrendered all its leases.

developed. Mr. Elicaño likewise did geologic exploration work in the vicinity of Calubian in the areas covered by the leases of the Union Oil Company, under the terms of an industrial fellowship. Geologic structures were found, but no drilling was done, and the leases were afterward submitted for cancellation.

Geologic exploration work was also undertaken in southeastern Mindoro, in the municipality of San Jose, by Daywalt and Company. Under the terms of an industrial fellowship Antonio D. Alvir, geologist of the Division of Geology and Mines, was sent to do the geologic work. He has submitted a report to Daywalt and Company, but as yet nothing further has been done. Mr. Elicaño had previously visited the area.

In Toledo, Cebu, the Visayan Petroleum Company was granted a lease during the latter part of 1921, but at this writing nothing has been done. It will be remembered that two wells had been drilled in this area in 1896 which reached 244 and 344 meters in depth, respectively. Petroleum was encountered and a small amount was produced.

In the Pidatan oil district the Mindanao Petroleum Company was granted leases in March, 1921. No development work was done, however, and the leases were afterward submitted for cancellation. The Round Mountain Petroleum Company and the Barclay Petroleum Company had drilling leases in the area, but nothing was done and their leases were canceled in 1923. The writer accompanied a geologic survey party to this district in 1920. Several months were spent in the field, and after completion of the systematic work on the fossils collected the chief geologist of the party will present for publication the scientific results of the expedition.

Persistent rumors regarding discovery of petroleum seepage in the vicinity of Antipolo, Rizal Province, led the Richmond Petroleum Company to apply for leases covering certain areas. When it became known that the Richmond Petroleum Company had made application for leases, an association of persons also applied for leases for contiguous areas. Doctor Dickerson of the Richmond Petroleum Company and Mr. Elicaño, working under the terms of a Bureau of Science industrial fellowship, made some preliminary investigations of the seepage. It was found that the district was not worthy of further exploratory work and the leases of the Richmond Petroleum Company were submitted for cancellation.

RESIDUAL BITUMENS

According to Smith [3] the bitumen that impregnates the Malumbang limestone series in northwestern Leyte, known commercially as rock asphalt, is to a large extent a paraffin residuum corresponding most nearly to the variety ozocerite. This is the material that has been developed by the Leyte Asphalt and Mineral Oil Company, and it has been successfully used as road material in Cebu and in other parts of the Philippine Islands. The greater part of the production has been shipped to Manila and Cebu. A small amount was sent to Japan for trial. The production in 1921 was only 766 metric tons, valued at 11,290 pesos. This was a marked decline from the production of 1920, which was approximately 2,000 tons and was valued at about 30,000 pesos. There has been no report of production for 1922 and 1923. The controlling interest in this company has changed hands and, according to reliable information, Japanese capital will undertake the development of the properties.

IMPORTATION OF "MINERAL CRUDE OIL" AND ASPHALT

The importation of "mineral crude oil" shows very marked increases during the last three years. The year 1922 represents the banner year, when 1,894,308 barrels were imported, valued at 5,337,775 pesos. In 1923 there was a slight decrease, the number of barrels totaling only 1,377,559, valued at 3,369,189 pesos. From the marketing viewpoint the most important event was the entry of the Associated Oil Company into the Philippines, which marked the beginning of a long price war. Table 1 shows the extent of importation of "mineral crude oil" from various countries during the last five years, taken from the annual reports of the Director of Customs. Table 2 gives the importation of asphalt for 1922 and 1923. Figures for 1921 are not available, as they were included under item "Residuum, including tar, and all others from which the light bodies have been distilled" in the Customs Report for 1921. The greater part of the imported asphalt is used in the construction, maintenance, and treatment of roads and pavements.

[3] Mineral Resources of the Philippine Islands for 1919 and 1920 (1922) 59.

TABLE 1.—*"Mineral crude oil" imported into the Philippine Islands, 1919–1923, by countries, in barrels of 42 United States gallons.*

Country.	1923		1922	
	Quantity.	Value.	Quantity.	Value.
	bbls.	*Pesos.*	*bbls.*	*Pesos.*
United States	1,047,178	2,279,024	1,759,034	4,890,906
United Kingdom				
Germany			1	56
British East Indies				
Dutch East Indies	330,381	1,090,165	135,251	446,261
Japan			22	552
Total	1,377,559	3,369,189	1,894,308	5,337,775

Country.	1921		1920		1919	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	bbls.	*Pesos.*	*bbls.*	*Pesos.*	*bbls.*	*Pesos.*
United States	1,017	8,799	140,512	1,519,006	4,894	34,236
United Kingdom	2	54	278	992		
Germany						
British East Indies	10,037	56,381	637	4,650	347	5,156
Dutch East Indies	174,598	889,229	114,868	485,576	63,371	313,047
Japan						
Total	185,654	954,463	256,295	2,010,224	68,612	352,439

TABLE 2.—*Asphalt imported into the Philippine Islands in 1922 and 1923, by countries*

Source.	1923		1922	
	Quantity.	Value.	Quantity.	Value.
	kg.	*Pesos.*	*kg.*	*Pesos.*
United States	1,865,634	79,019	1,224,055	60,280
United Kingdom			2,550	133
Czechoslovakia	1,114	38		
Germany	16	3	125	10
Dutch East Indies	844	64		
Australia			170	200
Total	1,867,608	79,124	1,226,900	60,623

NONMETALS

By ANTONIO D. ALVIR

CEMENT

Since the closing of the plant of the Rizal Cement Company at Binangonan, Rizal Province, in March, 1919, there was no production of Portland cement in the Philippines up to October 1, 1923, when the Cebu Portland Cement Company at Naga, Cebu, started grinding clinker. On the other hand, the importation of cement has been growing steadily. Table 1 shows the countries from which the Islands imported cement, in the order of their importance, during 1921, 1922, and 1923. The year 1920 is included for the purpose of comparison, although it was an unusual year. In 1920 our importations of cement amounted to 503,992 barrels, valued at 3,240,458 pesos. In 1921 imports fell to 290,128 barrels, valued at 2,005,264 pesos. In 1922 imports amounted to 306,704 barrels, valued at 1,587,383 pesos, and in 1923, 318,517 barrels, valued at 1,417,424 pesos. Our consumption of cement, based upon the importation of this commodity during the last three years, probably amounts to an average of 1,500,000 pesos a year. In the last three months of 1923 the Cebu Portland Cement Company produced 37,557 barrels of cement, but it was too late in the year to have any effect on the importation of cement during that year. Most of the imported cement comes from Japan; however, importation is heavy also from the French East Indies, China, Hongkong, Germany, and Denmark.

In order to make use of the extensive raw cement materials at Naga, Cebu, and partially to supply the local needs of the cement industry, the Cebu Portland Cement Company was formed and a modern cement plant built at Naga, Cebu. The following brief account of the plant and the operations is made possible through the kindness of Hon. Alberto Barretto, president of the Cebu Portland Cement Company, and F. D. Reyes, chemist of the Bureau of Science, who was sent to Naga, Cebu, to make an examination of the cement plant.

TABLE 1.—*Portland cement imported into the Philippine Islands, 1920–1923, by countries.*

Country.	1923			1922		
	Quantity.	Value.	Average value per barrel.	Quantity.	Value.	Average value per barrel.
	bbls.	*Pesos.*	*Pesos.*	*bbls.*	*Pesos.*	*Pesos.*
Japan	74,040	388,908	5.25	169,646	894,773	5.27
French East Indies	34,546	109,997	3.18	78,877	357,616	4.53
China	73,026	310,695	4.25			
Hongkong	16,483	86,338	5.24	21,809	125,318	5.75
Canada				20,071	92,175	4.59
Germany	47,772	208,755	4.37	8,105	46,470	5.73
Denmark	32,622	105,682	3.24			
United States	3,562	27,235	7.65	7,247	62,867	8.77
United Kingdom	14,909	84,245	5.65	31	1,517	48.94
Italy	9,550	54,696	5.73			
Belgium	8,560	27,718	3.24			
Sweden	2,930	9,633	3.26			
British East Indies	54	354	6.57	905	6,459	7.14
Norway	483	3,168	6.56			
Spain						
France				13	188	14.46
Netherlands						
Total	318,517	1,417,424		306,704	1,587,383	

Country.	1921			1920		
	Quantity.	Value.	Average value per barrel.	Quantity.	Value.	Average value per barrel.
	bbls.	*Pesos.*	*Pesos.*	*bbls.*	*Pesos.*	*Pesos.*
Japan	175,001	1,161,773	6.62	365,789	2,314,327	6.36
French East Indies	28,337	98,407	3.47	42,063	127,998	3.42
China				24,730	219,536	8.87
Hongkong	30,390	242,863	7.79	42,538	358,361	8.43
Canada	43,997	406,852	9.25			
Germany						
Denmark						
United States	12,254	91,870	7.50	27,798	208,694	7.51
United Kingdom	17	1,021	60.06	17	1,120	65.88
Italy	106	1,217	11.49			
Belgium						
Sweden						
British East Indies						
Norway						
Spain	16	1,161	72.56	1,057	10,422	9.84
France						
Netherlands	10	100	9.58			
Total	290,128	2,005,264		503,992	3,240,458	

THE CEBU PORTLAND CEMENT COMPANY

The Cebu Portland Cement Company was organized with C. F. Massey as president and general manager, and a cement plant was built at Naga, Cebu, following the recommendations of a former geologist of the Bureau of Science who reported that extensive raw materials for the manufacture of Portland cement exist in the locality. The National Development Company was the largest stockholder in the Cebu Portland Cement Company, with C. F. Massey, the only other stockholder, holding 120,000 pesos worth of stock. In August, 1923, the plant, which cost 2,600,000 pesos, was ready to begin operations, but it was not until October 1 that the plant began to produce cement. During October, November, and December, 1923, it produced 37,557 barrels of cement.

The plant is situated near the seashore in Tinaan Barrio, Naga, Cebu, 22 kilometers south of the City of Cebu. The Philippine Railway passes near by and a railroad siding connects the cement factory with the railroad station at Tinaan; the provincial road also passes near the plant. A brief description of the operation follows:

The rock is first crushed in an electrically driven Jumbo crusher, after which the material is delivered by gravity to a hammer pulverizer and then delivered by a belt conveyor to the wet compeb hopper or to the storage piles. The wet compeb mill is a rotary grinder driven by a 500 horse power Allis Chalmers alternating current motor. It is fed either by the belt conveyor or by the locomotive crane. Water is introduced with the material. The wet compeb is capable of grinding 450 tons of material daily. A bucket elevator takes the slurry from the compeb to either of the four steel slurry storage tanks, each of which is 20 feet in diameter by 30 feet high. The slurry is here agitated by compressed air and then analyzed. If it is of the right composition it is sent directly to the supply tank of the rotary kiln; if not, the slurry goes to one of the two correcting tanks, where the desired composition is acquired by drawing from one or all of the four slurry storage tanks. From the correction tank the slurry is raised by a bucket elevator to the supply tank of the rotary kiln. The kiln is about 175 feet long and has a diameter of about 10 feet. Its speed of rotation is controlled from the burning platform. The gases pass through two steel dust collecting boxes, then through a waste-heat boiler and finally

to a Green fuel economizer. A fan between the fuel economizer and the chimney creates the desired draft in the kiln. The factory was designed to operate with the waste-heat boiler alone, but there is an auxiliary boiler which can be used if needed. Normally the kiln produces 1,000 barrels of clinker per day but, according to Mr. Reyes, 1,250 barrels could easily be produced. A bucket elevator takes the hot clinker to the clinker storage, where there is a traveling electric crane. The clinker grinding machine (dry compeb) is similar to the wet compeb, only it requires much greater power. An electric crane loads the clinker from the piles to the dry compeb hopper. Gypsum amounting to 3 per cent of the clinker is added to each bucket. This compeb can grind about 1,400 barrels of cement per day. The ground cement is taken up by a bucket elevator into three steel tanks, which have a capacity of 5,500 barrels each. A screw conveyor underneath the tanks delivers the cement to the packing room. Four barrels can be filled simultaneously in about five minutes. There is also a bag-filling machine with a capacity of 500 pounds per hour.

The coal used in the kiln is first passed through a rotary drier, heated externally. Then it is fed into a grinding mill similar to but smaller than the compeb mills. The powdered coal is then delivered to a steel tank which automatically gives the weight of the coal, and from there it is blown into the coal bin of the rotary kiln.

A waste-heat water-tube boiler, working at 175 pounds pressure and rated at 609 brake horse power, furnishes the steam to a horizontal turbine which drives the main 1,250-kilowatt generator. Another smaller unit of 125 kilowatts is used in case the kiln is not in operation. An air compressor supplies the compressed air for the slurry tanks, the correction tanks, and the powdered coal.

RAW MATERIALS

The raw materials are obtained from several places. The hard limestone (high lime) comes from the quarries about 4 kilometers up the hills, the graywacke (68 per cent silica) a short distance from the plant, and the low lime is obtained by means of a steam shovel at the plant site.

The following analysis of the average composition of the raw materials is given for comparison:

TABLE 2.—*Analysis obtained from factory records.*

Constituent.	Soft high lime near plant.	Hard lime 4 kilometers away.	Low lime near plant.
	Per cent.	*Per cent.*	*Per cent.*
Loss, water, carbon dioxide (H_2O, CO_2)	36.95	38.36	25.20
Silica (SiO_2)	11.48	10.34	32.72
Calcium oxide (CaO)	46.10	47.60	30.10
Iron oxide (Fe_2O_3)	1.58	1.42	2.43
Aluminium oxide (Al_2O_3)	5.16	4.38	8.65
Magnesium oxide (MgO)	0.94	1.06	1.33

The analysis (Table 2) shows that the soft high lime is just as good as the hard limestone taken from up the hills, and that the high lime and the low lime can be combined so that the desired composition for cement may be obtained without the use of graywacke. Near the factory the upper layer of the quarry site has high lime, whereas the lower portion contains low lime. These materials are mined with a steam shovel.

The gypsum used comes from Talahib, Lobo, Batangas. In 1923, 402.2 tons were received at the factory, but only 160 tons were used. About 65 per cent of the coal used at the plant is supplied by the Uling Coal mines.

GRADE OF PRODUCT

The product turned out by the Cebu Portland Cement Company is known as Apo cement. The Bureau of Science has conducted tests on the Apo cement. Tests were also made by E. R. Dovey, Government analyst at Hongkong. The results of both tests were very satisfactory. Dovey's analysis showed that Apo cement more than meets all British specification requirements. His analysis, which has appeared in a pamphlet of the Chino American Industrial Developing Company, Limited, Hongkong, is presented here as Tables 3 and 4. Results of tests by the Bureau of Science with Apo cement are presented in Tables 5 and 6.

TABLE 3.—*Hongkong Government analysis of Apo cement, by E. R. Dovey, Government analyst.*

[Sample of cement submitted 16th October, 1923.]

	Per cent.
Moisture	0.10
Silica (SiO_2)	21.17
Total insoluble matter	1.27

TABLE 3.—*Hongkong Government analysis of Apo cement, by E. R. Dovey, Government analyst*—Continued.

	Per cent.
Iron oxide	2.92
Alumina (Al_2O_3)	6.54
Lime (CaO)	61.75
Magnesia (MgO)	1.26
Sulphuric anhydride (SO_3)	1.48
Carbonic anhydride	2.66
Alkalies and loss	0.85
Total	100.00
Loss on ignition	2.76
Hydraulic modulus	2.23

TABLE 4.—*Results of tests of Apo cement.*

	Test by Hongkong Government of Apo cement.	British Government specification requirements.
Soundness	Perfect.	Perfect.
Fineness:		
Residue on 180 × 180 sieve (32,400 meshes per square inch) ---------- Per cent	6.94	[a]14.00
Residue on 76 × 76 sieve (5,776 meshes per sq. in.)----do----	0.452	[a]1.00
Specific gravity	3.982	
Freshly burnt and ground	----------	[b]3.15
Four weeks old	----------	[b]3.10
Setting time:		
Initial---------- minutes--	195	----------
Quick setting----do----	----------	[b]2
Medium setting----do----	----------	[b]10
Slow setting----do----	----------	[b]20
Final----do----	380	----------
Quick setting----do----	----------	[b]10 to [a]30
Medium setting----do----	----------	[b]30 to [a]120
Slow setting----do----	----------	[b]120 to [a]420
Tensile test:[c]		
Neat cement—		
7 days---------- lbs. per sq. in --	[d]704	[b]450
28 days----do----	[d]778	[b]538
Sanded (1 :3 mortar)—		
7 days---------- lbs. per sq. in --	[d]360	[b]150
28 days----do----	[d]453	[b]250

[a] Maximum. [b] Minimum. [c] Breaking strain of briquettes 1″ × 1″ section. [d] Average.

TABLE 5.—*Results of tests of Apo cement.*

	Test by Bureau of Science, of Apo cement.	Philippine Government specification requirements.
Physical requirements:		
Fineness (passing 200-mesh)..... per cent..	85	80
Soundness (5 hours).....	Sound.	Sound.
Specific gravity.....	3.10	3.10
Setting time—		
Initial..... minutes..	280	60
Final.....do....	430	600
Tensile strength (1:3 mortar)—		
7 days ..... lbs. per sq. in ..	294	200
28 days.....do....	390	300
3 months.....do....	405	----------
6 months.....do....	419	----------
12 months.....do....	436	----------

TABLE 6.—*Chemical analysis of Apo cement, compared with chemical requirements of Government specifications for Portland cement.*

	Bureau of Science analysis.	Philippine Government specification requirements.
	Per cent.	*Per cent.*
Loss on ignition.....	1.92	4.00
Insoluble residue.....	----------	0.85
Sulphuric anhydride (SO_3).....	1.34	2.00
Magnesia (MgO).....	1.44	5.00
Silica (SiO_2).....	21.80	----------
Ferric oxide (Fe_2O_3).....	3.35	----------
Alumina (Al_2O_3).....	6.15	----------
Lime (CaO).....	64.00	----------

GYPSUM

The most important gypsum locality in the Philippines is in Batangas Province, Luzon. Some gypsum was mined in Talahib, Lobo, Batangas, when the Rizal cement plant was working in Binangonan. When the Cebu Portland Cement Company commenced operations in August, 1923, the development of these gyspsum deposits was again started. The Philippine Gypsum Corporation is at present producing gypsum from the locality and supplying the needs of the Cebu Portland Cement Company. Its mines are located in Talahib Barrio, Lobo, Batangas. Mr. Elicaño, chief of the Division of Geology

and Mines, visited this deposit, and from his report the following is taken:

The deposit is in the form of fissure vein fillings in andesite, ranging from a few inches to 4 feet in width. The deposit may be the result of acid ascending solutions coming in contact with calcareous descending waters. The presence of limestone on top of the andesite some distance from the deposit would seem to indicate that limestone probably covered the region where the deposits are at present. The deposit probably derived its calcium from the limestone, through the agency of the descending waters. The acidity, if not originally in the ascending solutions, might be due to the oxidation of the pyrite which is abundant in the andesite, resulting in the formation of sulphuric acid. Development work has not been pushed far enough to warrant an estimate of the amount of the deposit or to provide definite criteria concerning the origin of the deposit and its probable extent in depth. It is reported that the quality of the gypsum improves with depth, but the diggings up to the present have reached a depth of only 6 to 7 meters. The deposits are only 3 kilometers from the shore, but transportation is a serious problem.

The Mabini deposits are very similar in appearance and form to the Talahib deposits and very probably had a similar origin. The vein is reported to be about 50 feet thick. No development work has been done on these deposits.

ROCK PHOSPHATE

The most important rock phosphate in the Philippines is guano. It is of wide occurrence, being found in all limestone localities, notably Luzon, Panay, Negros, Leyte, Bohol, Marinduque, and Mindoro, and is generally encountered in caves. The principal source is the excrement of animals, mostly bats and birds, that dwell in the caves. The guano is mixed with limestone breccia and travertine which have been phosphatized through the leaching of the guano. The guano is generally pulverulent at the top, but becomes compact with depth. There is considerable variation in the deposits of the several caves. Some are granular, porous, and friable, and are white, pink, black, or yellow; others are dense, massive, and homogeneous, and are white or yellow. One of the latest localities to come to the notice of the Bureau of Science is Dumarao, Capiz, which was investigated by Mr. Elicaño, under the terms of an industrial fellowship.

MISCELLANEOUS

Clay products.—The manufacture of native pottery by crude and primitive methods is very widespread in the Philippines. Due to the fact that most individual producers keep no record of their production, the data are never complete, and the amount produced is not accurately known. However, the manufacture of clay products is an industry that commands attention. Our imports of earth and clay, manufactured and unmanufactured, including brick, chalk, tableware, porcelain, flower-pots and stands, sewer pipes and conduits, tiles, etc., amounted to 781,366 pesos in 1921, 964,678 pesos in 1922, and 1,007,055 pesos in 1923, thus showing a steady increase. We import mostly from Japan, China, the United States, and the United Kingdom. Our clay products are peculiar to the Islands and do not compete with imported earth and clay products. At present local products consist of native kitchen pottery, small water jars, clay stoves, and other objects; in some places like Tinajeros and Pasig, Rizal Province, the people make a specialty of large water containers called "tina" and "tinaja," or "tapayan." In Los Baños, besides the clay from which Los Baños pottery is made, there is also a white clay which is utilized as a paint material. Another locality that supplies clay suitable for cold-water paint is found in Tinambac Barrio, San Vicente, Camarines Norte Province.

Building stone.—The quarrying of building stone is one of our important mineral industries. Adobe stone, "batong sillar," and Guadalupe stone are popular names applied to consolidated volcanic tuff that occurs as a continuous blanket material from Lingayen Gulf to southwestern Luzon. It is the most popular building material in the provinces and is being quarried in Meycauayan, Bulacan; Balintawac and Guadalupe, Rizal; and other places. Most of this tuff was laid under water. The stratification is very regular; and sorting, which is very apparent, is responsible for the coarse and fine varieties. Marble is still quarried in Romblon in small quantities, most of it being utilized in the form of chips used as ornaments in concrete facings. In Cebu and other places there is a hard coral limestone which has been used for building purposes.

Rock, sand, and gravel.—Crushed stone for road construction is obtained locally. Basalt, andesite, and limestone are generally used, but volcanic tuff is also quarried in some places for the same purpose, although it does not make a satisfactory road

material. Sand and gravel used in construction and road building are obtained mostly from river beds, and the prices vary according to haulage distance. Beaches and shore lines also furnish considerable quantities.

Mineral water.—W. D. Collins,[1] of the United States Geological Survey, defines mineral water as—

> water that is bottled and sold in its natural state or only slightly altered from its natural state. It includes (*a*) natural carbonated waters that have lost part of their carbon dioxide; (*b*) natural waters that have been artificially carbonated; and (*c*) waters from which iron has been removed. It does not include artificial waters or natural waters that have been essentially modified in chemical character * * *.
>
> Three uses of mineral waters are recognized in this report—table use, medicinal use, and use in manufacture of soft drinks—but the quantity and value of water used in the manufacture of soft drinks are not included in the totals.

Mineral waters as now understood do not include artesian water that is not bottled and sold, such as the water produced by the artesian wells drilled by the Bureau of Public Works. During 1921 the Bureau of Public Works drilled 102 artesian wells, in various parts of the Islands. In 1922 the number was 97, and in 1923, 76 were drilled.

Sibul Spring water is bottled and sold for medicinal use. It is also used by two factories in Sibul Springs for the manufacture of soft drinks. "Isuan" is bottled at Los Baños, Laguna. Table 7, showing imports and exports, indicates the extent of the mineral-water industry.

TABLE 7.—*Imports and exports of artificial and natural mineral waters from 1920 to 1923, inclusive.*

Year.	Imports.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	Liters.	*Pesos.*	*Liters.*	*Pesos.*
1920	572,934	211,093	10,310	5,092
1921	481,600	187,616	815	300
1922	291,505	149,256	----------	----------
1923	290,101	141,455	5,136	515

Lime.—In many localities where limestone is abundant, and generally where it is of the soft variety, it is burned in primitive kilns to produce lime. The product is used extensively

[1] Mineral Resources of the United States, 1921, Part 2, Non-Metal; p. 229—Mineral Waters.

in sugar mills. A small quantity is prepared for utilization as building material by mixing it with sand. In other places, where sea shells are abundant, there are also small primitve lime kilns in which the shells are burned.

Salt.—Salt continues to be produced in many parts of the Islands, mostly by solar evaporation of sea water. The production, of course, varies directly with the length of the dry season, and a prolonged drought usually means large production. Salt making is one of our important native industries. In spite of the large production some salt is also imported (see Table 8).

TABLE 8.—*Imports and exports of salt in 1920–1923, inclusive.*

Year.	Imports.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	kg.	*Pesos.*	*kg.*	*Pesos.*
1920	156,634	24,260	3,622,729	101,862
1921	77,996	13,258	177,359	6,678
1922	130,153	15,341	229,188	6,977
1923	5,258,991	131,436	34,351	1,116

LIST OF MINERAL LAND CONCESSIONS GRANTED AND IN FORCE TO DECEMBER 31, 1923

By LEOPOLDO A. FAUSTINO

In response to many inquiries received at the Bureau of Science regarding the status of our mineral lands, the Bureau of Lands was requested to prepare a list of all mineral land concessions granted since American occupation, and the list is here presented in tabular form. In 1902 the old Mining Bureau published Bulletin 2, which contains a complete list of Spanish mining claims recorded at that time. The list here presented gives all the patented claims as well as all coal and petroleum leases, to and including December 31, 1923, in accordance with the present mining laws.

List of mineral land concessions granted and in force to December 31, 1923.

LODE PATENTS.

No.	Location.	Mineral.	Patentee, lessee, or permittee.	Area.
				Hectares.
1	Itogon, Benguet	Gold	H. Clay Clyde	9.2903
2	Mankayan, Bontoc	do	Thomas Newcomb	9.1145
3	do	do	Albert P. Wright	5.4953
4	do	do	B. L. Baker	4.0710
5	do	do	Alvin M. Pettit	8.3299
6	Itogon, Benguet	do	Clyde M. Eye	4.7329
7	do	do	Nels Peterson	8.6289
8	do	do	do	9.2903
9	do	do	do	9.2903
10	Araroy, Mashate	do	August Heise	9.2903
11	do	do	Guy W. Parsons	9.1178
12	do	do	B. H. Berkenkotter	5.1530
13	do	do	Frank W. Brown	8.7366
14	do	do	do	9.1399
15	do	do	Blaine F. Moore	9.2903
16	do	do	do	9.2903
17	do	do	August Heise	2.4309
18	do	do	do	9.2903
19	do	do	George W. Moore	9.2617
20	Itogon, Benguet	do	Con Shea	9.0000
21	do	do	do	9.0000
22	do	do	Mary C. Francis	9.0000
23	do	do	Richard T. Laffin	9.0000
24	do	do	Percy G. McDonnell	9.0000
25	do	do	Maurice F. Loewenstein	9.0000
26	do	do	George C. Sellner	7.0857
27	do	do	Josephine Whitmarsh	8.1510
28	do	do	Richard T. Laffin	7.4764
29	do	do	Arthur F. Odlin	8.3025

List of mineral land concessions granted and in force to December 31, 1923—Continued.

LODE PATENTS—Continued.

No.	Location.	Mineral.	Patentee, lessee, or permittee.	Area.
				Hectares.
30	Itogon, Benguet	Gold	Thomas C. Kinney	9.0000
31	do	do	Leonard Lehlbach	9.0000
32	do	do	Richard P. Strong	8.2137
33	do	do	Perry Iams	9.0000
34	do	do	do	9.0000
35	do	do	Hugh P. Whitmarsh	9.0000
36	do	do	Leonard Lehlbach	9.0000
37	do	do	Thomas C. Kinney	4.4199
38	do	do	Jerome B. Thomas	9.2903
39	do	do	Mrs. Anna J. McDill	9.2903
40	do	do	John R. McDill	9.2903
41	do	do	Mrs. Anna J. McDill	9.2903
42	do	do	John R. McDill	9.2903
43	do	do	Mrs. Anna J. McDill	9.2903
44	do	do	John R. McDill	9.2903
45	do	do	do	9.0000
46	do	do	do	9.0000
47	do	do	do	9.0000
48	do	do	Mrs. Anna J. McDill	4.6675
49	do	do	John R. McDill et al	5.7735
50	Aroroy, Masbate	do	Colorado Mining Co	7.7289
51	do	do	Ben. E. Lear	7.9254
52	do	do	Colorado Mining Co	9.0000
53	do	do	H. B. McCoy	5.0447
54	Itogon, Benguet	do	Camote Clayton Mining Co	9.2903
55	do	do	do	8.3665
56	Aroroy, Masbate	do	Colorado Mining Co	8.6620
57	do	do	Edras Herbert	9.0000
58	do	do	H. B. McCoy	8.0927
59	do	do	Edward B. Bruce	8.7446
60	do	do	Estate of E. Cromwell	6.5598
61	do	do	Ben. E. Lear	6.2988
62	do	do	Edward B. Bruce	8.9994
63	do	do	Colorado Mining Co	5.3494
64	do	do	do	9.0000
65	do	do	F. W. Brown	8.9930
66	do	do	Guy W. Parsons	8.6205
67	do	do	B. H. Berkenkotter	9.0000
68	do	do	John T. Pickett	7.5694
69	do	do	George N. Hurd	9.0000
70	do	do	do	9.0000
71	do	do	B. H. Berkenkotter	9.0000
72	Itogon, Benguet	do	John F. Reavis	3.7521
73	do	do	Benguet Cons. Mining Co	0.7149
74	do	do	L. O. Hibberd	9.0000
75	do	do	J. G. Lawrence	9.0000
76	do	do	Benguet Cons. Mining Co	9.2903
77	do	do	do	9.2903
78	do	do	A. W. Beam	9.0000
79	do	do	Charles C. Cohn	6.6814
80	do	do	C. M. Eye	8.8563

List of mineral land concessions granted and in force to December 31, 1923—Continued.

LODE PATENTS—Continued.

No.	Location.	Mineral.	Patentee, lessee, or permittee.	Area.
				Hectares.
81	Itogon, Benguet	Gold	C. M. Eye	2.7778
82	do	do	Benguet Cons. Mining Co	3.3341
83	do	do	J. G. Lawrence	6.3350
84	do	do	C. H. Sleeper	9.0000
85	Tuba, Benguet	do	Demonstration, Ltd	2.7290
86	do	do	do	4.3429
87	do	do	do	9.0000
88	Mankayan, Bontoc	do	Paula Oliva and J. Gaffney	9.0000
89	do	do	P. M. Moir	9.0000
90	do	do	Hiram Leonard	7.9135
91	do	do	J. E. Gaffney	9.0000
92	Tuba, Benguet	do	Demonstration, Limited	9.0000
93	do	do	do	9.0000
94	Mankayan, Bontoc	Copper?	V. E. Lednicky	7.9383
95	Tuba, Benguet	Gold	Demonstration, Limited	4.3314
96	Itogon, Benguet	do	J. W. Noble	9.0000
97	do	do	A. D. Tanner	6.4268
98	do	do	do	0.9857
99	Mankayan, Bontoc	Copper	Gladys Lednicky	0.2963
100	do	do	J. A. Lednicky	8.5347
101	do	do	V. E. Lednicky	8.0736
102	do	Gold	A. W. Hora	8.0864
103	do	do	Geo. M. Icard	6.8239
104	do	do	do	8.4057
105	do	do	Wm. Woodward	9.0000
106	do	do	W. W. Weaver	7.1485
107	Itogon, Benguet	do	William Ebert	9.0000
108	do	do	Benguet Cons. Mining Co	0.2909
109	do	do	William A. Ebert	9.0000
		PLACER PATENTS.		
1	Mankayan, Bontoc	Gold	Albert P. Wright	5.5887
2	Peñaranda, Nueva Ecija	do	Maximiano Carlos	7.8276
3	do	do	Fred L. Dorr	7.8276
4	do	do	Maximiano Carlos	8.0000
5	do	do	Fred L. Dorr	7.9894
6	do	do	Sotero de Guzman	7.9894
7	Mulanay, Tayabas	Oil	E. W. McDaniel	7.6620
8	Twin Peaks, Benguet	Gold	Stonewall J. Humphreys	6.9138
9	Binangonan, Rizal	Building stone	The Rizal Quarry Co	12.9880
10	do	do	Jennie Caronna	37.3276
11	do	do	The Rizal Quarry Co	39.2925
12	do	do	Perfecto Gabriel	7.5601
13	do	do	B. W. Rice	17.4654
14	do	do	The Rizal Quarry Co	17.1505
15	Mambulao, Camarines Norte	Iron	A. G. Zoboli et al	64.0000
16	do	do	do	64.0000
17	do	do	Frank B. Ingersoll et al	32.0000
18	do	do	do	32.0000

List of mineral land concessions granted and in force to December 31, 1923—Continued.

COAL PATENTS.

No.	Location.	Patentee, lessee, or permittee.	Area.
			Hectares.
1	Bulalacao, Mindoro	Antonio de Yrıbar	34.6180
2	Danao, Cebu	Carmen Fabrice	64.0000
3	do	Maria Acuña	64.0000
7	Cataingan, Masbate	William H. Donovan	32.0000
8	Naga, Cebu	Edmond Block	64.0000
	COAL LEASES.		
1	Toledo, Cebu	W. Huse Chapman	1,120.0000
2	Rapu-Rapu, Albay	Leon Rosenthal	400.0000
3	Naga, Cebu	John W. Ford	606.8787
4	Rapu-Rapu, Albay	J. E. Barker	400.0000
5	Danao, Cebu	D. M. Carman	400.0000
6	Rapu-Rapu, Albay	Edward C. Walters	400.0000
7	Toledo, Cebu	J. Clayton Nichols	924.6276
	COAL REVOCABLE PERMITS.		
1	Toledo, Cebu	Edgar B. Cummings	4.0000
1	Naga, Cebu	Pedro Pañares de Garcia	4.0000
2	Calolbon, Albay	Marcelino Reyes	4.0000
3	Toledo, Cebu	William G. Pauly	4.0000
4	do	Isidoro Enriquez	3.9000
5	Buruanga, Capiz	Federico B. Sarabia	4.0000
8	Minglanilla, Cebu	Apolinar Abella	3.1000
9	Toledo, Cebu	Manuel Enriquez	4.0000
10	do	Juan Ariate	4.0000
12	do	Eugenio Enriquez	1.2000
13	do	Teofilo Rivera	4.0000
16	do	Placido Alferez	4.0000
18	Naga, Cebu	Teofilo Rivera	4.0000
20	Toledo, Cebu	Lorenzo Libumfacil	4.0000
22	do	Martiniano Evangelista	4.0000
23	do	Mamerto A. Engbino	4.0000
26	do	Restituto Cepada	4.0000
27	do	Monico Adlawan	4.0000
28	Buruanga, Capiz	Rosario M. Gonzales	4.0000
29	do	Inocenta Jimenez	4.0000
32	do	Paulino Maatuban	4.0000
35	Cebu, Cebu	Aquilino Codilla	4.0000
36	Toledo, Cebu	Aurelio Villaflor	4.0000
38	do	Mariano Yap	4.0000
39	do	Charles E. Bolt	4.0000
40	Naga, Cebu	Vicente Canonigo	3.9996
42	Toledo, Cebu	Arcadio Jaca	4.0000
44	do	Teofilo L. Chiong	4.0000
47	Naga, Cebu	Luis Belleza	4.0000
48	do	Ambrosio Natad	4.0000
49	do	Moises Veloso	4.0000
52	Dalaguete, Cebu	Faustino Bajarias	4.0000

List of mineral land concessions granted and in force to December 31, 1923—Continued.

COAL REVOCABLE PERMITS—Continued.

No.	Location.	Patentee, lessee, or permittee.	Area.
			Hectares.
53	Toledo, Cebu	Angel Yriarte	1.0000
54	do	Juan Pardillo	4.0000
55	do	Anastasio Rama	4.0000
56	do	Antonio Juarez	4.0000
57	Naga, Cebu	Agustin Kintana	4.0000
58	Toledo, Cebu	Alberto Villaver	4.0000
60	Manjuyod, Cebu	Guillermo Villanueva	4.1000
61	Naga, Cebu	Martin Silgas	4.0000
62	do	Bernardo Pañares	4.0000
63	Toledo, Cebu	Narciso Abarquez	4.0000
64	do	Norberto A. Cabia	3.0000
65	do	Restituto Villordon	4.0000
66	Danao, Cebu	Hilario Toledo	4.0310
67	do	Vicente Villarino	4.0306
68	do	Apolonio Toledo	4.0510
69	Toledo, Cebu	Pedro Alforque	4.0000
70	do	Cresencio S. Ocampo	4.0000
75	Naga, Cebu	Jacinto Daclan	3.0000
76	Dalaguete, Cebu	Fidel Natad	4.0000
77	do	Pedro Caballero	4.0000
78	Naga, Cebu	Manuel Tan	4.0000
80	Toledo, Cebu	Josefina Gonzales	4.0000
81	do	Primitiva Abarquez	3.0000
82	do	Quintin Reivera	4.0000
83	Rapu-Rapu, Albay	E. J. Haberer	1,290.0000
84	Dalaguete, Cebu	Juan Yñigo	4.0000
	PETROLEUM DRILLING LEASES.		
1	Mulanay, Tayabas	Richmond Petroleum Co	1,187.8140
2	do	do	1,200.0000
3	do	do	1,199.9960
9	San Narciso, Tayabas	E. W. McDaniel	390.0000
10	do	Tayabas Oil Land Ass	699.0000
11	do	E. W. McDaniel	100.0000
14	Mulanay, Tayabas	Richmond Petroleum Co	1,200.0000
15	do	do	289.5751
16	do	do	800.0000
17	do	do	1,200.0000
18	do	do	1,000.0000
19	do	do	1,200.0000
23	San Narciso, Tayabas	E. W. McDaniel	395.0000
24	Cebu, Cebu	Visayan Petroleum Co	400.0000
31	Mulanay, Tayabas	Richmond Petroleum Co	1,200.0000
34	do	do	1,200.0000
35	do	do	1,200.0000
36	do	do	1,200.0000
37	do	do	1,200.0000
38	do	do	1,200.0000
39	do	do	1,200.0000
40	do	do	300.0000

List of mineral land concessions granted and in force to December 31, 1923—Continued.

PETROLEUM DRILLING LEASES—Continued.

No.	Location.	Patentee, lessee, or permittee.	Area.
			Hectares.
41	Mulanay, Tayabas	Banisilan Oil Co	1,080.0000
42	do	do	1,200.0000
43	do	do	1,200.0000
44	do	do	1,200.0000
45	do	do	1,200.0000
53	do	do	1,200.0000
54	do	do	1,200.0000
55	do	do	1,200.0000
56	do	do	1,200.0000

GEOLOGICAL EXPLORATION LEASES.

No.	Location.	Mineral.	Patentee, lessee, or permittee.	Area.
				Hectares.
1	Villaba et al, Leyte	Petroleum	Richmond Petroleum Co	18,000.0000
3	do	do	Banisilan Oil Co	18,000.0000
4	do	do	William Anderson	12,200.0000
5	San Jose, Mindoro	do	Daywalt & Co	18,000.0000
8	Villaba, Leyte	do	William Anderson	18,000.0000
9	do	do	Banisilan Oil Co	3,600.0000

BENGUET CONSOLIDATED MILL.

THE GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1924 AND 1925

ISSUED BY THE DIVISION OF GEOLOGY AND MINES
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Benguet Consolidated mill, Antamok, Mountain Province, Luzon.

PLATE 1

Preliminary geologic map of the Philippine Islands.

PLATE 2

Relief map of the Philippine Islands.

PLATE 3

Mineral map of the Philippine Islands.

PLATE 4

Climate map of the Philippine Islands.

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1924 AND 1925

INTRODUCTION

By VICTORIANO ELICAÑO

A quarter of a century has passed since the establishment of the Mining Bureau (the present Division of Geology and Mines of the Bureau of Science) in 1900.

It has been decided to signalize the end of a quarter century of service by the publication of a Philippine mines handbook, which will contain more or less complete accounts of the mineral resources and the mineral industries of the Philippine Islands. The Mineral Resources of the Philippine Islands for the years 1924 and 1925 is to serve the purposes and needs of a Philippine mines handbook.

The present work contains statistical tables of the mineral production of the Philippines, by years and by provinces. The growth of the industry is graphically shown by figures, and the centers of production are noted at a glance.

A geographic and geologic description of the Philippine Archipelago, with an account of its geologic history, is included in order to serve as a background for the proper understanding of the condition of development of the mineral resources and the mineral industries.

As an introduction to an account of the present development of the mineral resources, a brief history of Philippine mining before and during Spanish occupation and since the American régime is given. The account of the present development is given for all economic minerals and mineral products known in the Philippine Islands.

A summary of the existing mining laws and regulations, together with proposed amendments designed to help the industry, is made a part of this issue.

Several maps are included; namely, a mineral map, a geologic map, a climate map, and a relief and hydrographic map.

The present issue of the Mineral Resources is intended to serve as a summary of information to possible investors. Of the basic

industries of the Philippines, mining has been the tardiest in development. Although the industry dates from the third century of the Christian era, and while the Spanish Government, the American Government, and the present Government appear to have done their best to promote the industry, in comparison with the other industries the production of minerals and mineral products has not kept pace with our economic development.

In spite of numerous setbacks, gold has been the steadiest in development. From a production of 187,647 pesos in 1907 the output kept increasing at a more or less regular rate, exceeding the million-peso mark in 1912, passing the two million-peso mark two years later, and in 1925 reaching the large sum of 3,891,979 pesos. Iron production is small but steady. In 1925 the total output amounted to 62,590 pesos. More copper was produced during the period from 1861 to 1874 than at any time since. A small production of copper was recorded in 1908, 1910, and 1911. In 1911 it amounted to about 600 pesos. Manganese was sporadic in development. In 1909 there was a small production. This was followed by a larger production in 1916, amounting to 30,000 pesos, but the next production was in 1918 and it was valued at only 9,000 pesos. There has been no development since that time, although a very small amount is sold to local foundries and battery factories. Platinum was first produced in 1922 as a by-product of gold-dredging operations in Lianga, Surigao.

The production of coal has had a checkered history. Production began as early as 1842 and from that year until 1906 it is estimated that about 29,952 long tons of coal were produced from the different mines. In 1913 production stopped for several causes, and there was no commercial production until 1917. The peak of coal production was reached in 1920, as an after-effect of the World War, when 57,960 long tons were produced.

There has never been any commercial production of petroleum in the Islands, although several localities are known to contain oil. Geologic explorations have been carried on in all of them, but only two localities were tested by drilling. Slight indications of petroleum and natural gas were encountered, but nothing approaching commercial quantities was found under the structures tested.

At the close of the World War several mineral industries were born, but these were short-lived. Small quantities of sulphur

and asbestos were produced in 1918 and 1919. From 1919 to 1921 a small amount of asphalt was produced.

There were two periods of cement production; the first from the latter part of 1915 to the early part of 1919, by the Rizal Cement Company at Binangonan, Rizal, the second from 1923 to the present time, by the Cebu Portland Cement Company at Naga, Cebu. The present production of gypsum began with the establishment of the Cebu Portland Cement Company. The value of clay products has been on the decrease, due in part to the curtailment of the production of bricks, roofing tiles, and the conical receptacles for sugar (*pilones*). With the increased production of sugar there has been an increase in the production of lime, and also an increase in the production of phosphate rock, which has been used as fertilizer. Road building and building construction throughout the whole Philippine Islands are reflected in the amount of sand, gravel, and crushed rock produced, which in 1925 amounted to more than one million pesos.

While the history of mining in the Philippines has been in the main a record of failures, it is not without its romantic episodes. Individuals and companies enjoyed apparent prosperity for two or three years, and one company has been able to maintain successful operations since 1914. This company is the Benguet Consolidated Mining Company, whose entire plant was carried away by a damaging flood in 1911, but it was able to recuperate and to-day is the outstanding example of a successful mine in the Philippine Islands.

Mine failures are to be expected in the development of the mineral resources of any country, and the Philippine Islands has not been an exception to this general rule.

STATISTICS OF MINERAL PRODUCTION

By LEOPOLDO F. ABAD

Mineral production for 1924 and 1925.—Statistics of mineral production for 1924 and 1925 are shown in Table 1. The important mineral products are iron, platinum, gold, silver, cement, clay products, coal, gypsum, lime, mineral waters, phosphate rock, salt, sand, gravel, crushed rock, and stone. The total value produced in 1924 was 7,342,875 pesos; in 1925 it was 8,027,924 pesos. The value of metallic products in 1925 shows an increase of 569,407 pesos over that of 1924, and 574,268 pesos over that of 1923. The increase was due to a much greater production of gold, silver, and cast iron. Only 137 grams of crude platinum were produced in 1925, while in 1924 there was no production. The value of nonmetallic products in 1925 increased to 3,980,535 pesos, or 115,642 pesos over that of 1924 and 747,573 pesos over that of 1923. The larger production in 1925 was due to the output of cement, gypsum, lime, phosphate rock, and sand, gravel, and crushed rock.

Mineral production by provinces.—Statistics of mineral production by provinces are published for the first time and are shown in Tables 2 and 3, which show the quantity and value of the mineral products produced in each province for 1924 and 1925; Table 2 presents the production for 1924, and Table 3 for 1925. Some of the data given in a few of the provinces are incomplete, due in part to failure to receive the necessary information from the provincial officials. The tables show at a glance the centers of industry of the different Philippine mineral products.

Mineral products of the Phihlippine Islands from 1664 to 1925, inclusive.—Statistics of mineral production by years, from 1664 to 1925, are shown in Table 4. Although statistics of production of some of the minerals have been available since 1664, no table of mineral statistics for the Philippine Islands was published until 1908, and it gave the production for the year previous, 1907. The total value of mineral products then was 234,092 pesos. In 1916 it amounted to 5,664,260 pesos, and in

1925 to 8,027,924 pesos. The phenomenal rise, from 234,092 pesos in 1907 to 8,027,924 pesos in 1925, within the short period of nineteen years, is due in part to increased production of gold and silver, in part to larger production of materials of construction, and in part to the method of collecting data.

I wish to acknowledge with thanks the hearty coöperation in the collection of mineral statistics of the provincial treasurers, district engineers of the Bureau of Public Works and other Government entities, various corporations, the mining companies, and others who have made possible the compilation of the tables herein given.

TABLE 1.—*Mineral production of the Philippine Islands for 1924 and 1925.*

Product.	1924		1925	
	Quantity.	Value.	Quantity.	Value.
		Pesos.[a]		*Pesos.*[a]
Metallic:				
Cast iron.....metric tons	273	55,213	398	62,590
Crude platinum[b].....grams	.....	.....	137	700
Gold.....fine grams	2,521,623	3,352,039	2,928,003	3,891,979
Silver[c].....do	1,680,419	70,730	2,132,521	92,120
Total value of metallic	.....	3,477,982	.....	4,047,389
Nonmetallic:				
Cement.....barrels	264,981	856,824	283,167	746,680
Clay products[d]	.....	197,001	.....	210,074
Coal.....tons, of 1,016 kg	47,183	593,453	47,912	618,822
Gypsum.....metric tons	1,360	25,848	1,704	42,066
Lime.....do	13,759	252,992	16,721	372,705
Mineral waters.....liters	188,056	68,161	209,861	78,223
Phosphate rock[e].....metric tons	6,528	99,750	7,528	114,750
Salt[f].....do	28,919	541,147	30,603	555,323
Sand, gravel, and crushed rock.....cubic meters	598,145	1,186,649	567,545	1,190,399
Stone, building and ornamental.....do	16,894	43,068	17,062	51,493
Total value of nonmetallic	.....	3,864,893	.....	3,980,535
Grand total	.....	7,342,875	.....	8,027,924

[a] One peso Philippine currency equals 50 cents United States currency.

[b] By-product from gold dredging.

[c] No silver is mined separately; the gold bullion produced carries from 5 to 30 per cent of silver as a natural alloy.

[d] A home industry, and includes pottery, brick, and tile.

[e] Estimated only.

[f] Evaporation of natural brine and ocean waters.

TABLE 2.—*Statistics of mineral production for 1924, by provinces.*

Province.	Cast iron.		Gold.		Silver.		Cement.		Clay-products.[d]	Coal.		Gypsum.	
	Metric tons.	Value.	Fine grams.	Value.	Fine grams.	Value.	Barrels.	Value.	Value.	Tons of 1,016 kg.	Value.	Metric tons.	Value.
		Pesos.[e]		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*		*Pesos.*		*Pesos.*
Abra									2,288				
Agusan													
Albay									5,400	10,394	134,590		
Antique									1,741				
Bataan									153				
Batanes									522				
Batangas									5,150			1,360	25,848
Bohol[c]													
Bukidnon													
Bulacan	273	55,213							2,355				
Cagayan									1,688				
Camarines Norte			128,163	170,358	23,030	910			(f)				
Camarines Sur									1,600				
Capiz									2,700				
Cavite													
Cebu							264,981	856,824	18,018	27,242	363,393		
Cotabato													
Davao[c]									(f)				
Ilocos Norte									8,016				
Ilocos Sur									7,235				
Iloilo									7,450				
Isabela													
Laguna									1,650				
Lanao													

La Union									10,069				
Leyte									604				
Marinduque									600				
Masbate			576,288	766,020	232,228	10,059			(f)				
Mindoro													
Misamis									340				
Mountain			1,809,768	2,405,819	1,423,854	59,709			(f)				
Nueva Ecija									2,094				
Nueva Vizcaya													
Occidental Negros									8,003				
Oriental Negros									1,463				
Palawan									12				
Pampanga									79,946				
Pangasinan									4,364				
Rizal									6,010				
Romblon									494				
Samar									132				
Sorsogon [b]									(f)				
Sulu									(f)				
Surigao [b]			7,404	9,842	1,307	52							
Tarlac									3,825				
Tayabas													
Zambales									4,809				
Zamboanga [b]									(f)	9,547	95,470		
Grand total	273	55,213	2,521,623	3,352,039	1,680,419	70,730	264,981	856,824	197,001	47,183	593,453	1,360	25,848

[b] No report received from provincial treasurer.
[c] No report received from district engineer.
[d] Includes tiles, bricks, pots, jars, pilones, and pipes.
[e] One peso Philippine currency equals 50 cents United States currency.
[f] Estimates added to grand total.

TABLE 2.—*Statistics of mineral production for 1924, by provinces*—Continued.

Province.	Lime.		Mineral waters.		Phosphate rock.[a]		Salt.		Sand, gravel, and crushed rock.		Building and ornamental stone.		Total value.
	Metric tons.	Value.	Liters (bottled.)	Value.	Metric tons.	Value.	Metric tons.	Value.	Cubic meters.	Value.	Cubic meters.	Value.	
		Pesos.		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*
Abra	19	380							8,659	29,786	(f)	(f)	32,446
Agusan									2,181	2,181			2,181
Albay	109	4,360							9,219	7,375			151,725
Antique	12	460					75	2,900	4,100	9,825			14,926
Bataan	1,500	1,500					43	1,908	1,520	3,770			7,331
Batanes	560	11,200					3	428					12,150
Batangas	513	9,183					867	34,690	17,006	10,308	715	890	86,069
Bohol[c]	4	102			4,000	60,000	41	1,012	(f)	(f)			61,114
Bukidnon													
Bulacan	408	7,614	4,375	918			653	12,387	1,652	9,967	9,296	14,025	102,479
Cagayan	3	75			(f)	(f)	16	635	5,829	25,492			27,890
Camarines Norte									6,410	7,981			179,249
Camarines Sur	50	500							15,256	33,114	(f)	(f)	35,214
Capiz	15	255					45	1,250	8,775	9,399			13,604
Cavite	20	280					14,000	165,000	3,037	7,551	11	108	172,831
Cebu	3,862	11,086	5,221	1,096	(f)	(f)	1,059	67,141	31,674	39,743			1,357,301
Cotabato									4,843	10,083			10,083
Davao[c]									(f)	(f)			
Ilocos Norte	193	1,926					123	5,593	16,924	24,884			40,419
Ilocos Sur	549	4,312					1,503	59,560	23,010	56,376			127,483
Iloilo	1,065	50,845			(f)	(f)	547	25,190	62,282	135,561			219,046
Isabela									1,433	5,015			5,015
Laguna	5	200	178,460	66,147					9,636	21,897	7	72	89,894
Lanao									5,185	11,833			11,833

La Union	237	2,370					270	14,812	11,063	10,786				38,037
Leyte									(f)	(f)				604
Marinduque	3	125			250	3,750	1	70	(f)	(f)				4,545
Masbate					(f)	(f)			4,293	12,447				148,526
Mindoro					(f)	(f)			5,300	9,880				9,880
Misamis							25	1,250	16,613	36,628				38,218
Mountain	10	150					(f)	(f)	6,858	14,445	(f)	(f)		2,480,123
Nueva Ecija									21,241	34,452				34,456
Nueva Vizcaya							37	4,686	5,295	13,144				17,830
Occidental Negros	78	775					8	560	37,824	68,875				78,213
Oriental Negros	10	80			(f)	(f)		5	5,547	9,609	(f)	(f)		11,157
Palawan							9	360	90	210				582
Pampanga									8,083	39,390				119,336
Pangasinan	26	765			(f)	(f)	590	13,528	40,633	31,491	(f)	(f)		50,148
Rizal	2,323	27,556					7,345	93,640	72,924	179,904	2,926	19,588		326,701
Romblon							(f)	(f)	2,503	5,450	[g]0.6	2,895		8,838
Samar	5	525					1	22	25,447	66,157				66,836
Sorsogon[b]	(f)	(f)							4,522	9,749	(f)	(f)		9,749
Sulu									10,700	25,260				25,260
Surigao[b]									1,838	5,219				15,113
Tarlac									12,468	26,804				30,629
Tayabas	2,103	114,873			500	7,500			11,804	45,047				167,420
Zambales	5	195			250	3,750	40	1,420	2,982	6,683				16,857
Zamboanga[b]	(f)	(f)					(f)	(f)	15,486	24,875	(f)	(f)		120,345
Grand total	13,759	252,992	188,056	68,161	6,528	99,750	28,925	542,147	598,145	1,186,649	16,894	43,068		7,342,875

[a] Estimated.
[b] No report received from provincial treasurer.
[c] No report received from district engineer.
[f] Estimates added to grand total.
[g] Marble.

TABLE 3.—*Statistics of mineral production for 1925, by provinces.*

Province.	Cast iron.		Crude platinum.		Gold.		Silver.		Cement.		Clay products.[d]	Coal.	
	Metric tons.	Value.	Grams.	Value.	Fine grams.	Value.	Fine grams.	Value.	Barrels.	Value.	Value.	Tons of 1,016 kg.	Value.
		Pesos.[a]		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*		*Pesos.*
Abra											2,150		
Agusan													
Albay											8,025	10,113	128,608
Antique											1,869		
Bataan													
Batanes											522		
Batangas											20,570		
Bohol [e]													
Bukidnon													
Bulacan	398	62,590									2,354		
Cagayan											1,933		
Camarines Norte					144,310	191,822	24,190	1,036			(f)		
Camarines Sur											2,700		
Capiz											2,700		
Cavite													
Cebu									283,167	746,680	18,070	23,033	342,554
Cotabato													
Davao [e]											(f)		
Ilocos Norte											10,227		
Ilocos Sur											5,376		
Iloilo											7,033		
Isabela													
Laguna											1,878		
Lanao													

La Union											10,069		
Leyte											720		
Marinduque											600		
Masbate					520,290	691,584	254,261	10,992			(f)		
Mindoro													
Misamis											340		
Mountain					2,226,623	2,959,685	1,847,625	79,834			(f)		
Nueva Ecija											2,094		
Nueva Vizcaya													
Occidental Negros											11,688		
Oriental Negros											1,948		
Palawan											18		
Pampanga											67,686		
Pangasinan											4,618		
Rizal											5,250		
Romblon											494		
Samar											134		
Sorsogon [b]											(f)		
Sulu											(f)		
Surigao [b]			137	700	36,780	48,888	6,445	258					
Tarlac											4,760		
Tayabas													
Zambales											5,778		
Zamboanga [b]											(f)	14,766	147,660
Grand total	398	62,590	137	700	2,928,003	3,891,979	2,132,521	92,120	283,167	746,680	210,074	47,912	618,822

[b] No report received from provincial treasurer.
[c] No report received from district engineer.
[d] Includes tiles, bricks, pots, jars, pilones, and pipes.
[e] One peso Philippine currency equals 50 cents United States currency.
[f] Estimates added to grand total.

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TABLE 3.—*Statistics of mineral production for 1925, by provinces*—Continued.

Province.	Gypsum.		Lime.		Mineral waters.		Phosphate rock.[a]		Salt.		Sand, gravel, and crushed rock.		Building and ornamental stone.		Total value.
	Metric tons.	Value.	Metric tons.	Value.	Liters (bottled).	Value.	Metric tons.	Value.	Metric tons.	Value.	Cubic meters.	Value.	Cubic meters.	Value.	
		Pesos.		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*
Abra			18	360							8,065	16,677	(f)	(f)	19,187
Agusan											1,348	1,298			1,298
Albay			122	4,880							7,995	6,396			147,909
Antique			17	680					61	2,438	4,100	9,825			14,812
Bataan			1,500	1,500					41	1,823	26,663	78,417			81,740
Batanes			594	11,875					4	495					12,892
Batangas	1,704	42,066	568	10,662					1,024	40,960	22,142	10,007	738	1,026	125,291
Bohol [e]			4	102			4,800	72,000	41	1,012	(f)				73,114
Bukidnon											13	20			20
Bulacan			394	7,411	3,521	739			747	13,810	1,473	9,765	8,374	11,992	98,361
Cagayan			3	33			(f)	(f)	18	720	1,405	5,149			7,887
Camarines Norte			55	548							4,321	4,736			198,142
Camarines Sur											18,527	39,869	(f)	(f)	42,569
Capiz			15	255					46	1,295	15,024	19,969			24,219
Cavite			20	280					14,350	167,000	17,019	18,084	11	108	185,364
Cebu			4,188	12,295	7,012	1,475	(f)	(f)	1,521	43,980	25,492	40,581			1,205,635
Cotabato											9,556	9,573			9,573
Davao [e]											(f)	(f)			
Ilocos Norte			286	2,289					169	8,242	4,526	6,294			27,052
Ilocos Sur			694	5,401					1,708	77,100	7,108	21,463			109,340
Iloilo			2,717	130,107			(f)	(f)	579	26,570	45,627	101,214			264,924
Isabela											4,132	14,462			14,462
Laguna					199,328	76,009					15,494	35,300	5	50	113,187
Lanao											1,180	2,631			2,631

La Union			237	2,370					270	14,812	11,020	10,866			38,117
Leyte											(f)	(f)			720
Marinduque			3	125			300	4,500	1	70	(f)	(f)			5,295
Masbate							(f)	(f)			4,004	8,846			711,422
Mindoro							(f)	(f)			8,100	15,800			15,800
Misamis									25	1,250	21,202	38,619			40,209
Mountain			65	972					(f)	(f)	8,104	20,432	169	3,301	3,064,224
Nueva Ecija											11,780	17,534			19,628
Nueva Vizcaya									31	4,680	2,670	6,612			11,292
Occidental Negros			99	988					10	700	23,138	75,122			88,498
Oriental Negros			10	80			75	140		5	6,827	11,774	(f)	(f)	13,807
Palawan									10	400	944	2,752			3,170
Pampanga											10,975	55,569			123,255
Pangasinan			26	772			(f)	(f)	942	18,908	42,030	33,886	(f)	(f)	58,184
Rizal			2,323	27,556					7,345	93,640	53,485	182,364	3,826	26,631	335,441
Romblon									(f)	(f)	2,503	5,450	g0.6	2,895	8,839
Samar			6	599					2	58	25,447	66,157			66,948
Sorsogon [b]			(f)	(f)							10,648	20,415	(f)	(f)	20,415
Sulu											2,026	2,026			2,026
Surigao [b]											6,235	15,502			65,348
Tarlac											10,782	23,168			27,928
Tayabas			2,678	148,700			600	9,000			12,452	49,187			206,887
Zambales			5	215			300	4,500	35	1,355	3,063	6,388			18,236
Zamboanga [b]			(f)	(f)							12,900	22,200	(f)	(f)	169,860
Grand total	1,704	42,066	16,721	372,705	209,861	78,223	7,528	114,750	30,603	555,323	567,545	1,190,399	17,062	51,493	8,027,924

[a] Estimated.
[b] No report received from provincial treasurer.
[c] No report received from district engineer.
[f] Estimates added to grand total.
[g] Marble.

TABLE 4.—*Mineral production of the Philippine Islands, from 1664 to 1925, inclusive.*

Year.	Metallic.														Total value of metallic.
	Crude platinum.		Gold.		Silver.		Copper.		Cast iron.		Iron ore.		Manganese.		
	Grams.	Value.	Fine grams.	Value.	Fine grams.	Value.	Kg. fine.	Value.	Metric tons.	Value.	Metric tons.	Value.	Tons.	Value.	
		Pesos. [a]		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*
1861–1874							113,636								
1664–1883									[c] 2,500	350,000					
1884									230	25,040					
1885–1901									[c] 600	70,000					
1902									56	6,400					
1903									70	15,900					
1904									123	20,170					
1905									116	18,400					
1906									125	18,000					
1907			141,212	187,647	2,582	110			132	19,536					207,293
1908			326,903	434,500	73,094	2,491	91	52	97	17,500					454,543
1909			372,564	495,194	93,312	3,120			78	31,078				12,500	541,892
1910			232,316	308,860	55,987	1,944	1,809	464	50	20,023					331,291
1911			285,846	379,906	105,225	3,606	1,100	600	73	29,159					413,271
1912			857,911	1,140,424	221,492	8,664			141	49,272					1,198,360
1913			[b] 1,306,310	1,736,724					227	64,471					1,801,195
1914			1,811,341	2,349,267	311,040	9,878			199	56,244					2,415,419
1915			1,981,587	2,633,528	486,917	15,665			96	22,694					2,671,887
1916			2,265,789	3,011,755	151,519	7,576			93	18,864			3,000	30,000	3,068,195
1917			1,990,468	2,645,784	81,578	4,895			66	17,936					2,668,615

1918	-------	-------	1,937,941	2,575,970	128,974	8,306	-------	-------	78	24,983	-------	-------	650	9,000	2,618,259
1919	-------	-------	1,970,651	2,619,449	261,558	18,828	-------	-------	67	34,964	18,598	92,990	-------	-------	2,766,231
1920	-------	-------	1,920,753	2,424,606	307,343	19,261	-------	-------	87	40,191	-------	-------	-------	-------	2,484,058
1921	-------	-------	1,976,096	2,626,192	814,621	33,614	-------	-------	174	39,225	-------	-------	-------	-------	2,699,031
1922	42	179	2,205,857	2,932,092	836,047	35,950	-------	-------	156	30,611	-------	-------	-------	-------	2,998,832
1923	420	1,791	2,537,162	3,372,654	1,174,976	49,400	-------	-------	269	49,276	-------	-------	-------	-------	3,473,121
1924	-------	-------	2,521,623	3,352,039	1,680,419	70,730	-------	-------	273	55,213	-------	-------	-------	-------	3,477,982
1925	137	700	2,928,003	3,891,979	2,132,521	92,120	-------	-------	398	62,590	-------	-------	-------	-------	4,047,389

[a] One peso Philippine currency equals 50 cents United States currency.
[c] Estimated.
[e] Includes value of alloyed silver.

TABLE 4.—*Mineral production of the Philippine Islands, from 1664 to 1925, inclusive*—Continued.

Year.	Nonmetallic.											
	Asbestos.		Asphalt and related bitumens.		Cement.		Clay products.[b]	Coal.		Gypsum.		Lime.	
	Metric tons.	Value.	Metric tons.	Value.	Barrels.	Value.	Value.	Tons of 1,016 kg.	Value.	Metric tons.	Value.	Metric tons.	Value.
		Pesos.		*Pesos.*		*Pesos.*	*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*
1861–1874													
1664–1883													
1884													
1885–1901													
1902													
1903													
1904													
1905													
1906								[d] 29,952	450,000				
1907								4,116	26,799				
1908							421,628	10,019	77,166				20,000
1909							422,840	30,287	197,184				69,656
1910							430,000	28,609	176,255				70,000
1911							450,000	19,968	130,000				90,000
1912							453,000	2,716	20,200				92,026
1913							460,000					11,050	102,700
1914							465,000					11,000	100,000
1915							475,000					12,520	144,000
1916					112,513	540,062	685,078					12,792	153,075
1917					108,808	702,900	900,000	5,658	141,425			14,000	270,000

1918	70	5,250			28,192	282,625	910,000	15,416	385,400			15,000	375,000
1919	375	37,500	1,400	21,000	10,396	124,752	700,000	32,374	822,300			20,000	534,000
1920			2,000	30,005			570,000	57,960	[f] 1,452,200			3,001	10,872
1921			766	11,290			264,011	39,445	808,626			3,558	150,127
1922							149,798	41,752	856,345			2,553	61,230
1923					37,557	255,387	142.859	42,762	874,441	402	8,040	3,224	97,044
1924					264,981	856,824	197,001	47,183	593,453	1,360	25,848	13,759	252,992
1925					283,167	746,680	210,074	47,912	618,822	1,704	42,066	16,721	372,705

[b] Includes bricks, tiles, pots, jars, and pipes.
[d] Estimated production from 1842 to 1906, inclusive.
[f] This is an average of abnormal postwar prices.

TABLE 4.—*Mineral production of the Philippine Islands, from 1664 to 1925, inclusive*—Continued.

Year.	Nonmetallic.												Total value of nonmetallic.	Grand total value.
	Mineral waters.		Phosphate rock.		Salt.		Sand, gravel, and crushed rock.		Stone, building and ornamental.		Sulphur.			
	Liters.	Value.	Metric tons.	Value.	Metric tons.	Value.	Cubic meters.	Value.	Cubic meters.	Value.	Metric tons.	Value.		
		Pesos.		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*		*Pesos.*	*Pesos.*	*Pesos.*
1861–1874														
1664–1883														
1884														
1885–1901														
1902														
1903														
1904														
1905														
1906														
1907													26,799	234,092
1908	268,440	53,688						206,000		149,930			928,772	1,383,315
1909	401,000	80,200				375,368		325,050		311,177			1,781,475	2,323,367
1910	230,000	46,000				380,000		293,456		372,575			1,768,286	2,099,577
1911	300,000	60,000			18,333	550,000		477,344		665,795			2,413.139	2,826,410
1912	264,871	55,849			19,147	574,511		468,758		651,049			2,315,385	3,513,745
1913	270,000	60,000			19,500	575,000	689,011	595,645	197,039	350,041			2,143,386	3,944,581
1914	293,381	50,000			20,000	590,000	723,461	625,429	206,890	367,543			2,197,972	4,613,391
1915	305,400	55,000			22,500	600,000	650,200	580,580	267,910	341,119			2,195,699	4,867,586
1916	3,523,630	82,994			24,750	742,500	657,937	587,547	211,044	344,871			2,596,065	5,664,260
1917	255,800	63,950			26,000	780,000	525,672	788,508	232,196	417,952			3,361,835	6,030,450

1918	200,000	50,000	------	------	30,000	900,000	483,061	724,591	307,619	553,714	72	11,140	3,915,095	6,533,354
1919	225,000	60,000	------	------	32,000	900,000	403,986	588,379	404,709	832,630	12	1,680	4,622,241	7,388,472
1920	479,817	121,000	------	------	62,383	1,401,307	627,774	1,228,332	49,373	311,861	------	------	5,126,711	7,610,769
1921	639,513	170,406	------	------	31,247	800,686	526,137	1,081,000	48,972	173,674	------	------	3,459,820	6,158,851
1922	558,200	142,356	2,050	40,007	69,345	605,277	418,238	797,827	57,097	91,049	------	------	2,743,889	5,742,721
1923	474,033	113,796	3,781	80,557	76,194	835,865	398,222	722,135	50,550	102,838	------	------	3,232,962	6,706,083
1924	188,056	68,161	[g] 6,528	99,750	28,919	541,147	598,145	1,186,649	16,894	43,068	------	------	3,864,893	7,342,875
1925	209,861	78,223	[g] 7,528	114,750	30,603	555,323	567,545	1,190,399	17,062	51,493	------	------	3,980,535	8,027,924

[g] Estimated.

GEOGRAPHIC AND PHYSIOGRAPHIC DESCRIPTION OF THE PHILIPPINE ISLANDS

By LEOPOLDO A. FAUSTINO

The Philippine Islands is a group of islands lying southeast of the mainland of Asia between 21° 10′ and 4° 40′ north latitude and between 116° 40′ and 124° 34′ east longitude. The number of islands is placed at 7,083, of which 466 have an area of 2 square kilometers or over; 2,441 are named and 4,642 unnamed. Most of those unnamed are merely rocky islets and reefs. The most northerly is Y'Ami Island, 104 kilometers from Formosa; the most southerly is Saluag, 4° 40′ from the equator and 48 kilometers east of Borneo. The thirty-seven larger islands with their areas are as follows:

Island.	Square kilometers.	Island.	Square kilometers.
Luzon	105,708	Guimaras	580
Mindanao	95,587	Tawitawi	572
Samar	13,271	Biliran	495
Negros	12,699	Sibuyan	445
Palawan	11,655	Siargao	427
Panay	11,520	Burias	401
Mindoro	9,826	Culion	386
Leyte	7,249	Dumaran	324
Cebu	4,390	Balabac	321
Bohol	3,975	Ticao	321
Masbate	3,250	Siquijor	319
Catanduanes	1,461	Samal	251
Basilan	1,248	Camiguin de Misamis	241
Busuanga	971	Panaon	199
Marinduque	899	Camiguin (Babuyanes group)	196
Jolo	837	Olutanga	191
Dinagat	777	Alabat	184
Tablas	666	Lubang	171
Polillo	653		

The boundaries of the Philippine Islands, as defined by treaty limits, inclose an area of approximately 1,825,000 square kilometers. The total land area is 297,917 square kilometers, more than twice the area of Java or Cuba, or practically the same as that of the New England States and New York State combined, but a little less than that of the British Isles. The

water area within the boundaries is 1,527,996 square kilometers, or about five times the land area.

At first glance the map of the Philippine Islands reveals several striking features, namely:

1. The irregular configuration of the Archipelago, the outline of which suggests a giant sloth sitting on its haunches, slightly inclined forward, the head and shoulders represented by Luzon, the vertebræ and ribs by the Visayan Islands, the pelvis by Mindanao, the forelegs by Palawan and Cuyo, and the hind legs by the Sulu group.
2. Sulu Sea between Palawan and Mindanao, the largest body of water surrounded by land areas.
3. The great extent of the general coast line, which reaches a total of 18,417 kilometers.
4. The mountainous character of the islands, the ranges generally running parallel and often in close proximity to the coast line.
5. The constructional plains lying between the mountainous areas, and the narrow and interrupted coastal plains.
6. The few large rivers, the streams generally short and swift.
7. The great variety of lakes of diverse origin.
8. The number of active and dormant volcanoes.
9. The coral reefs fringing the shores of most of the islands.

For the purposes of this paper only the larger land areas will be described. To facilitate description the two larger islands, Luzon and Mindanao, have been divided into several physiographic provinces. Those of Luzon are briefly described under the following heads:

Western Cordillera.
Great Central Plain.
Cordillera Central.
Cagayan Valley.
Eastern Cordillera.
Southwest volcanic region.
Southeast volcanic region.

LUZON

Western Cordillera.—The Western Cordillera is generally known as the Zambales Range. It extends from Bataan north into Pangasinan Province and consists of two parallel, disconnected mountain ranges, separated by a structural valley. The eastern range consists of the line of peaks from Mount Mariveles north to Mount Pinatubo; the western range begins with Cinco Picos Mountains west of Subic Bay and follows the coast line.

The southern portion of the eastern range consists of two mountain masses; the first has Mount Mariveles with an elevation of 1,420 meters, and the second, Mount Natib with an elevation of 1,281 meters. These are separated by a mountain gap, through which runs a trail from Pilar on Manila Bay to Bagac on the west coast. North of Mount Natib and separating it from Mount Balakibok (elevation 947 meters) and Mount Dangas (elevation 991 meters) is a higher gap, through which a telegraph line passes from Dinalupihan to Olongapo. North of this gap is a cluster of mountain peaks, of which Mount Pinatubo, with an elevation of 1,781 meters, is the highest. Mount Pinatubo has a comblike peak and was once considered the highest point in the cordillera.

North of the Pinatubo mountains and separating them from the main western range of the cordillera is a mountain gap through which passes the trail from O'Donnell in the central plain to Iba on the western coast. The western range attains its maximum development north of this pass, and the topography is very rugged. The highest peak is called High Peak and has an elevation of 2,338 meters. The range continues northward but, upon reaching Pangasinan, it breaks up into several smaller ranges and at its northern extremity consists of low rolling hills with an average elevation of about 90 meters.

The structural valley between the eastern and western ranges is heavily filled with alluvial deposit. This structural valley is joined at its northern and southern extremities by transverse valleys leading to the coast. On account of the porous condition of the valley bottoms and the absence of rains during certain times of the year, this portion of the district presents the appearance of a semiarid region. A narrow, interrupted coastal plain extends from San Antonio north to Pangasinan.

In general, the rocks of this region are volcanic extrusives, principally andesites, with marls, shales, and volcanic agglomerates on the flanks, although in certain parts serpentine, cherts, and schists are also found. The Cinco Picos Mountains are dense pyroxenite. The foraminiferal tuffaceous marls are found on the coast near Santa Cruz, while a great mass of agglomerate is found on the eastern flank in the vicinity of Floridablanca and Camp Stotsenburg.

Great Central Plain.—The Great Central Plain extends from Manila Bay on the south to Lingayen Gulf on the north. It is bounded on the west by the Western Cordillera and on the

east by the Eastern Cordillera. The region is low-lying and almost flat. Mount Arayat rises, a solitary peak, to a height of 1,040 meters in the middle of the area. The northern and southern portions are largely composed of alluvial material with pyroclastics, while the southeastern portion is made up largely of pyroclastics. The northern portion is the delta region of Agno River. This river rises in Mount Data in the Cordillera Central and flows southward in a structural valley, but upon reaching the central plain it turns southwest, then west, and finally northwest, making a complete turn, to empty into Lingayen Gulf by way of a series of channels. Agno River is unnavigable but is important as a source of water for power and irrigation.

The southern portion of the Great Central Plain is the vast delta region of Pampanga River. This river rises in the Eastern Cordillera, flows along its western border, and turns slightly west of south to Manila Bay. At its lower end it breaks up into a network of canals, which anastomose with those of other streams from the center and the western margin of the southern half of the Central Plain, presenting a fine example of "braided" stream. Pampanga River is navigable for steamers of light draught as far as Mount Arayat, a distance of about 100 kilometers, and for rafts as far as Cabanatuan, about 200 kilometers. The river in most parts is wide and shallow with low mud banks. East of this river and parallel to it is the long and narrow Candaba Swamp.

Another large river rising in the Eastern Cordillera is the Angat. This river, incised deeply in a great lava flow on the edge of the cordillera, flows south, then turns sharply to the west, debouching onto the plain north of Manila.

The striking feature of the drainage system in this area is the fact that in the north the rivers flow to the north and in the south to the south. This condition may be explained by warping or merely irregular deposition of detrital material.

Cordillera Central.—The Cordillera Central extends from the northern boundary of the central plain to the northernmost point of Luzon. It consists of three ranges with a north-and-south direction: The Malaya Range on the west, average elevation of peaks about 1,800 meters; the Central Range, average elevation of peaks 1,800 to 2,400 meters; and the Polis Range on the east, average elevation of peaks 1,500 to 2,100 meters. The highest point in the Cordillera Central is Mount Pulog, 2,924

meters. Mount Data, where the Agno, the Abra, and the Chico and the Magat (two principal tributaries of Cagayan River) rise, has an average elevation of approximately 2,800 meters.

In this physiographic province is included the narrow elevated coastal plain extending from near the head of Lingayen Gulf to Cape Bojeador. In its widest portion the tract is not more than 20 kilometers wide.

The region is one of very pronounced relief. The torrential precipitation, the high altitude, and the short distance to the sea have aided in the quick work of the streams in making the topography irregular and rugged. The valleys are in the main V-shaped, and the valley walls are steep. Falls and rapids are common in the main channels and, on account of the terrific scouring by mountain floods, there is rarely an accumulation of wash. Slides and slumps are also common.

There are three large streams in this region, all rising in Mount Data. The Agno flows south to the Central Plain of Luzon. The Magat and the Chico are main tributaries of Cagayan River. The Abra flows north until it reaches the town of Dolores; then it turns abruptly westward and breaks through a coastal range of hard igneous rocks. This river is navigable for only rafts and dugouts.

In this region the development of valleys in islands with high mountain ranges is well illustrated. The river rising in high mountains has its torrent portion, where erosion is greatest, and its river portion, where transported material is being deposited on account of slackened flow. The river portion usually has a river channel, occupied at low water, and the alluvial flat, or flood ground, which is mostly covered with water during floods.

The rocks west of Polis Range are in the main volcanic extrusives, principally andesites, excepting a narrow strip of granite, 8 to 10 kilometers wide, between the central range and the Polis Range. The Polis Range consists mostly of folded, faulted, and eroded sedimentaries and sandstones and shales. In the igneous formations we find the relief irregular, rugged, and accentuated, with here and there a saw-toothed sky line; but in the sedimentaries the topography is more regular and the slopes present long gentle inclines. The narrow coastal plain consists in part of raised coral reefs and in part of alluvium overlying older sediments.

Cagayan Valley.—Cagayan Valley is a basin of varying width, occupying the low ground between the Cordillera Central and the Sierra Madre Mountains of the Eastern Cordillera. The basin is drained by Cagayan River. This river is about 300 kilometers long and flows almost due north, but meanders considerably in its lower course. It has two large tributaries, the Chico and the Magat. It is navigable for ocean-going vessels of light draught as far as Tuguegarao, a distance of 100 kilometers, and for boats drawing not over a meter of water as far as Echague, a distance of 200 kilometers.

The basin consists in the main of alluvium and detrital material from the surrounding higher areas, with pyroclastics. The valley is a synclinal trough formed by the down-bending of the sedimentary strata caused by orogenic disturbances.

Eastern Cordillera.—The Eastern Cordillera extends from the northernmost point of Luzon and follows pretty closely the east coast of Luzon, but upon reaching the northern portion of Tayabas Peninsula it divides into two parts, one part continuing as the backbone of Tayabas Peninsula, the other trending almost east and west across Caramoan Peninsula. The highest peaks in this cordillera average about 1,200 meters in elevation. The region is but little known. The northern portion is very close to the sea and is steep-cliffed. Mount Cagua in Cagayan, about 40 kilometers south of Cape Engaño, has an elevation of 1,197 meters. There are several mountain passes through this cordillera which connect the eastern coast with the interior. The most important of these passes is the one from Nueva Ecija, the Cabanatuan–Baler Trail, which separates two important massifs of the Eastern Cordillera. This trail does not go above 250 meters. The only road to the east coast is the Atimonan Road, in southeastern Luzon.

The rocks in this region are in the main volcanic intrusives and extrusives with closely folded sedimentaries. In Caramoan Peninsula there are schist areas. The complicated geology of the district has produced a very rugged topography.

Southwest volcanic region.—The southwest volcanic region comprises, roughly, the provinces of Rizal, Cavite, Laguna, and Batangas, and a portion of southwestern Tayabas. This area is characterized by mixed topography, in part plain and in part hilly and mountainous. It includes such prominent physiographic features as Laguna Lake, Taal Volcano and Lake, the

extinct cones of Banahao (elevation 2,188 meters) and Maquiling (elevation 1,144 meters) and others, and several small crater lakes near San Pablo and Pasig River.

The area is underlain with volcanic materials, mainly tuff, andesitic lava, and agglomerate. There are also limestones, conglomerates, sandstones, and shales, and in places along the coast littoral and alluvial deposit.

Laguna de Bay is roughly heart-shaped with three lakes extending northward. It is very shallow throughout, the deepest soundings recorded being 6.5 meters, and it covers an area of 930 square kilometers. The floor of the lake is fairly level. The lake receives drainage from numerous small streams on all sides, and is drained in turn by Pasig River, which has cut through an uplifted volcanic tuff.

Lake Taal, is roughly oval in outline and covers an area of 267.5 square kilometers. It is comparatively deep; soundings of 177 meters are recorded. The water of the lake finds an outlet to the sea through Pansipit River. Near the center of the lake is a small island, on which is located Taal Volcano.

Southeast volcanic region.—The southeast volcanic region comprises the whole of Bicol Peninsula and includes a cluster of more or less dormant volcanoes—Mayon, Isarog, and Bulusan. The highest of these, and the most famous on account of its almost perfect cone, is Mount Mayon, a short distance from Legaspi. Mount Mayon has an elevation of 2,421 meters. These volcanic mountains are of recent origin, and the flows are generally basaltic. West of this cluster of volcanic mountains is the narrow Bicol plain, which is composed mainly of river alluvium and volcanic ejecta.

The principal drainage of the area is Bicol River, which rises in Bato Lake and flows northwest into San Miguel Bay. This river is navigable for ocean-going interisland vessels as far as Naga (Nueva Caceres) and for flat-bottomed boats and dugouts for a considerable distance upstream.

MASBATE

Masbate's two-pronged shape is due to the junction of two prevailing anticlinal trends of the Visayan Islands and central Luzon. The western prong consists of a narrow coastal plain and a continuous range of hills, rising steeply until Mount Gantal (elevation about 600 meters) is reached. The eastern prong is not a continuous range, but is broken by two trans-

verse valleys. It is very rugged and mountainous. The highest point on the island is Mount Simbahan, elevation 660 meters. The crests of the mountain ranges are near the northern shore, while on the southwestern side of the main prong is a considerable stretch of plain and piedmont country.

The two cordillera ranges consist in part of older sediments, largely slates, intruded by diorites and more basic plutonic rocks, associated with later volcanic rocks and accompanying pyroclastics, and in part of later sedimentaries, mostly limestones, sandstones, and shales with a large development of conglomerate in certain parts.

MINDORO

Mindoro is a mountainous island with high mountain ranges running north and south and is extremely rugged and densely wooded. A transverse valley separates the Mount Halcon mass, or northern half, from the Mount Baco mass, or southern portion, and is the route of the only trail communication across the island. The highest point on Mindoro is Mount Halcon, elevation 2,587 meters. Mount Baco has an altitude of 2,487 meters. A narrow, very much interrupted coastal plain is present, which attains its maximum development in the raised coastal tract near Calapan on the northern shore and in the alluvial plain of San Jose on the southern coast. In places the mountains are very close to the sea. Lake Naujan is in the northeastern part.

The rocks of this island are in the main diorites and andesites. On the north there are some metamorphics, principally schists, and on the south Tertiary sedimentaries, mostly sandstones and shales with some limestones, are found.

PALAWAN

Palawan is a long, narrow island, a portion of the land bridge that once connected the Philippine Islands with Borneo. It is very rugged. The high mountains are in the south, the highest peak with an elevation of 2,073 meters. The mountains in the central part are a little lower, while in the north the topography is more or less rolling, with average elevations of 600 meters. Several transverse valleys cross the island from east to west and separate the main mountain masses. The coastal plain of Palawan is little developed, but a very extensive development of coral growth is found off all the coasts.

In the center and south of Palawan crystalline rocks predominate, mostly schists, while limestone is the chief formation in the north. There is likewise a considerable area of volcanic

extrusives and there are some shales and sandstones. In the limestone region there are numerous short gullies, ravines, and valleys which discharge their waters into caves or subterranean tunnels. One of these subterranean passages finds an outlet into St. Paul's Bay, and is the famous underground river of Palawan.

PANAY

Panay is roughly triangular in shape. The main cordillera runs almost north and south, starting in the extreme northwest corner of the island, swinging a little to the east, then turning to the southwest corner, almost paralleling the western coast. This cordillera lies much nearer to the western coast than to the eastern. The highest point on the cordillera is Mount Nangtud in the central part, elevation 2,050 meters. There are very few passes across these mountains. In the northeastern part of the island is a cluster of mountains, with peaks varying from about 400 to 600 meters, but no true cordillera. Between the two high mountain ranges lies the Central Plain of Panay, with an area of about 40 by 100 kilometers. It is formed by the coalescing of two great alluvial plains, the one formed by Panay River, flowing north, and the other formed by Jalaur River, flowing south. A low divide separates the northern portion of the plain from the southern area.

The core of the main cordillera is igneous, principally andesites, and some basic plutonic rocks, while the foothills are mainly limestones, shales, and sandstones. The Central Plain is alluvial-filled valley. The lower part of this plain is chiefly delta.

NEGROS

Most of Negros is mountainous. The main cordillera of the island runs northeast-southwest, close to the east coast for the most part. It is rugged and consists in the main of greatly eroded, folded, and faulted mountains. These rarely exceed 1,000 meters in height and their distance to the east coast rarely exceeds 2 or 3 kilometers. The streams on the east coast are short and swift. In the northern part of the island is a line of volcanic mountains, of which the most famous is Canlaon, rising to an elevation of 2,438 meters. Between the volcanic mountains are comparatively low areas with elevations ranging from 200 to 300 meters. The northwestern portion

of the island consists of an extensive coastal plain which flanks the line of older and younger volcanoes and rises gradually from the coast to the high areas with a gently sloping terrane. The striking feature of this volcano plain is the incised meanders of the streams.

A considerable portion of Negros is volcanic in origin. The entire eastern strip and a large portion of the southern part consists of folded and faulted Tertiary sediments, plutonic rocks, slates and jaspers of probable Mesozoic age, and some Tertiary extrusives, all more or less dissected and worn down by erosion. The northwestern coastal plain is in part due to volcanic ejecta during the Pliocene and later eruptions, in part to the work of streams, and in part to the work of shore currents.

CEBU

Cebu is long, narrow, and mountainous with a maximum elevation of about 1,000 meters. A narrow coastal plain fringes the island. The central cordillera has several mountain passes, through which communication has been established between the two coasts. One of these is the route of the Cebu–Toledo road; another is the Cebu–Barili road.

A characteristic feature of the topography of Cebu is the coves, or *cuencas,* so called by Abella. These are roughly circular or oval with floors not over 30 meters above the sea, and are located along the main streams. The floors are usually in shale or marl, the hilltops are limestone, while the lower ends are restricted by a hard igneous rock in the form of a dike or a laccolith. There are practically no navigable streams.

The dominant rocks of the central cordillera are igneous and metamorphics, which are partly mantled by sedimentaries and extrusives. The sedimentaries are Tertiary and consist in the main of sandstones and shales, which are folded and faulted. The sediments include the coal beds. Capping the whole mass is a superstructure of coral formation, which in places is maturely dissected. The coastal plain is for the most part slightly elevated coral platform with a thin veneer of alluvium spread out in broad fans by the streams from the mountains behind.

The soil in the uplands is thin on account of heavy mechanical erosion, but the coves, or cuencas, have thick beds of clayey and silty material.

BOHOL

Bohol is almost circular, with a fairly regular coast line. A semicircular range of mountains stretching from the western coast to the central part separates the drainage areas of the two main streams, the Mabanga in the north and the Loay in the south. The highest elevation on these mountains is about 800 meters. The most striking feature of Bohol is the remarkable series of "haycock" hills (hundreds of them) in the central part near Carmen. A narrow tract of interrupted coastal plain is present.

There is considerable igneous rock in the central and eastern part, but the dominant formation of Bohol consists in the main of sedimentaries, principally limestones.

LEYTE

The dominant feature of Leyte is the Central Cordillera, which divides the island into an eastern and a western part, running from Cabalian in a northwesterly direction through the island and continuing in Biliran and Maripipi Islands. It is for the most part rugged, and there are many high peaks. The highest elevation is Mount Lobi near the central part, 1,349 meters. This Central Cordillera is broken by several mountain passes, the sites of telegraph lines, and trails from both coasts. The southwestern district is semimountainous, as is a portion of the northeastern district, but from Carigara to Tacloban is low ground, the northeastern plain of Leyte. There are also some littoral lowlands of small extent.

The Central Cordillera is a volcanic belt. The rocks are mostly andesites. The most widespread formation is a series which contains (besides conspicuous beds of limestone) some shales, sandstones, and conglomerates, which are in part folded and faulted and in part intruded by igneous rocks apparently closely related to the igneous rocks of the cordillera. The northeastern plain is largely alluvial, while the marginal littoral deposits are formed in part by coralline limestone.

SAMAR

Samar is somewhat like a trapezium in shape and, unlike the other islands of the Archipelago, there is no great "cordillera central." The mountains are low, not exceeding 1,000 meters in height, and without any definite alignment. The

general character of the topography is rolling with extremely numerous, wide but shallow rivers.

The igneous rocks in Samar are limited in extent, occurring principally in the northwestern part. In the central part are isolated patches of volcanic extrusives with accompanying pyroclastics. The dominant formation is a series consisting of beds of limestone, some shales, sandstones, and conglomerates, much faulted, folded, and greatly eroded.

MINDANAO

Mindanao is the second largest island of the Philippine group, and has a very much indented coast line and some remarkably fine bays and harbors. The island is, roughly, shaped like a cooking pot with Zamboanga Peninsula as the handle. The following divisions of Mindanao will be briefly described:

Zamboanga Peninsula.
Lanao-Bukidnon Upland.
Agusan Valley.
Diuata Range.
Matutum Range.
Cotabato Valley.
Tiruray Table-land.

Zamboanga Peninsula.—This district comprises the long, narrow, mountainous Zamboanga Peninsula, of moderate elevation, and the high mountain ranges to the northeast. The larger streams in this district are on the north flanks of Mount Dapiak, elevation 2,617 meters, and Mount Malindang, elevation 2,425 meters. The southern part of the high mountainous area is well dissected and has a number of indentations. A small development of coastal plain near Zamboanga at the southernmost extremity is present.

The mountainous area of the northeast consists in the main of volcanic extrusives, basalts, and andesites, partly mantled by sedimentaries, and is exceedingly rugged. The elbow of the peninsula is a metamorphic area, mainly schists, while the lower end is composed of sharply flexed sedimentaries with a veneer of volcanic material. The topography is rugged with short, shallow, and swift streams. The coastal plain, approximately 12 by 35 kilometers, is an upraised coral beach.

Lanao-Bukidnon Upland.—The Lanao-Bukidnon Upland is a rolling grassland lava plateau of about 600 meters in elevation with deep canyons. Lake Lanao, elevation 686 meters, is included in this area. Mount Katanglad, elevation 2,379 meters, lies a little to the east of the center of the district and dominates the whole plateau. Several fairly large streams flow north

into Macajalar Bay. A narrow, interrupted coastal plain borders the area to the north, while its southern boundary is the line of dormant and extinct volcanoes of the Buldun Range. The drainage system of this elevated region is very complicated.

The rocks in this region are mostly volcanic extrusives, principally basalts. A narrow belt of sedimentaries along the coast is present, consisting mainly of limestones, shales, and sandstones.

Agusan Valley.—Agusan Valley is the seat of Agusan River and occupies the low country between the Diuata Range and the Lanao-Bukidnon Upland. The most striking feature of this district is the coalescing of four large streams in the middle part of the area, resulting in the formation of a great flat "sink," which comprises about 700 square kilometers and consists of a network of canals connecting lakes and marshes. There are few isolated patches of dry land within this marshy area, even during the so-called dry season of Agusan. Agusan River rises in Mount Tagnibay in the southern part of the Eastern Cordillera of Mindanao, and flows a little west of north parallel to the eastern ranges. It is navigable for steam launches as far as Bunauan, a distance of more than 100 kilometers. Agusan Valley is approximately 150 kilometers long and its average width is about 25 kilometers. The northern portion is part of the narrow coastal plain of Mindanao. It is a rift valley and has been the scene of repetitive faulting.

The materials composing this valley are in part detrital material brought down by the rivers, in part the basal rock brought to the surface by frequent earth movements. The soil is fine alluvium with considerable silty and clayey material.

Diuata Range.—The Diuata Range represents the Eastern Cordillera of Mindanao. It consists of two mountain systems, the Diuata Mountains proper in the north and the southern mountains, separated by a broad expanse of rolling country that probably does not exceed 600 meters in elevation. The highest point in the Diuata Mountains is a little over 1,800 meters, but Mount Japao in the southern mountains is 2,652 meters high. The region is characterized by exceedingly rugged topography, due in part to its location, near the border of the continental horst. The mountain ranges are very close to the sea.

The rocks composing this range are in the main volcanic extrusives, principally andesites and basalts, and basic plutonic rocks, with patches of sedimentaries, mainly sandstones, shales,

and limestones. Igneous intrusions are common and have produced metamorphism in certain parts.

Matutum Range.—Matutum Range consists of an irregular, interrupted chain of old volcanoes east of Cotabato Valley. Mount Apo, the highest peak in the entire Philippine Islands, with an elevation of 2,929 meters, is in the center of the range. Mount Matutum, the next highest point in Mindanao, is about 80 kilometers south and is separated by a rolling country of about 600 meters elevation. The range continues southward and forms the backbone of the Sarangani Peninsula, where it has an average elevation of about 1,400 meters.

The rocks in this region are in the main andesites, partly flanked by sandstones, shales, and limestones.

Cotabato Valley.—Cotabato Valley lies between the Lanao-Bukidnon Upland and the Tiruray Table-land. It is largely made up of low lands along Cotabato River and is of a more or less triangular shape. A portion of this low land is marsh area and is occupied by the Libungun marsh and the Liguasan marsh. A true delta formation is at the lower end of Cotabato River and extends inland to the junction of the two main branches at Tumbau. The valley attains its greatest width in the district of Kabakan. To the north and east of this district appear low hills and rolling topography, with some fairly high elevations.

Cotabato River rises in the Lanao-Bukidnon Upland, flows north for some distance, and then turns completely around and flows south to the southern boundary of Bukidnon Province. It makes a few swings and then follows a general southwest direction into Illana Bay. Meanders are common in this river. It is navigable as far as Kabakan, a distance of about 100 kilometers, for light, flat-bottomed boats, drawing not over a meter of water.

The rocks in this valley consist in the main of sedimentaries, mostly sandstones and shales, which are greatly folded and much faulted. There are patches of volcanic extrusives (mostly andesites and basalts), some coralline limestone, and volcanic agglomerate with accompanying pyroclastics.

Cotabato River overflows its banks periodically, thus enriching the soil, which is in the main silty and clayey. The color of the soil varies greatly, from reddish ferruginous clay to brownish loamy sand, to darker silty material.

Tiruray Table-land.—Tiruray Table-land is the upland country south of Cotabato Valley. Little is known of this district

except that the mountains are very close to the sea, the coast line is fairly regular, and the skyline is almost uniform. Some of the peaks in the central part of the district appear to be old volcanic cones. The average elevation is about 1,600 meters.

SULU ARCHIPELAGO

Sulu Archipelago is a host of small islands rising above a submarine bank, which extends from near Zamboanga Peninsula southwest to Borneo. The largest of these islands are Jolo, Tawitawi, Pangutaram, Siasi, and Sibutu. Jolo is almost entirely covered with volcanic material, either basalt, tuff, or loose ash. Tawitawi is reported to be largely made up of sedimentaries. Siasi is covered with volcanic material, and Sibutu is merely a raised coral shelf just above sea level; it is perfectly flat except for one hill in the center.

The soil in this region consists in the main of red ferruginous clay (decomposition products of volcanic material), and in places is deep.

GENERAL GEOLOGY AND GEOLOGIC HISTORY OF THE PHILIPPINE ISLANDS

By LEOPOLDO A. FAUSTINO

The Philippine Archipelago lies at the edge of the Asiatic continental platform. The great fore-deep is very close to its eastern margin, and the second deepest part of the Pacific Ocean is located about 85 kilometers northeast of Mindanao. To the west is the much lesser deep of the China Sea, presumably a sunken area. Two long, comparatively narrow, interrupted land bridges connect the Philippines to Borneo; one by way of Palawan, the other by way of the Sulu Archipelago.

The present land areas of the Philippines are merely the higher portions of a partly submerged mountain mass, in part the crests of anticlinal folds, in part the upthrust blocks caused by faulting, in part the flows from the volcanoes. The outline of the Archipelago was first marked at the close of the Paleozoic, during the Permian revolution, when a movement of the Asiatic land mass to the south caused the China Sea depression and crumpled the edge of the continental platform. In other words, the Philippine Islands formed the barrier that separated the waters of the Pacific Ocean from the waters of the present China Sea. It cannot be stated whether or not any portion was above water. It is reasonably certain, however, that the major diastrophism, which occurred in the late Paleozoic, marked the position of these islands and formed the major tectonic axes. Still later, in the Paleozoic, there were intrusions into the existing rocks of diorite, granodiorite, and granite; these marked the first period of ore deposition in the Archipelago.

The period following was characterized by deposition of fine-grained sediments which were laid in deep waters. These sediments are the Jurassic cherts, slates, and schists, which are found in small patches on Luzon, Panay, Negros, Cebu, and Mindanao. The cherts contain radiolarians, but no fossils have been found in the slates. Interbedded with the slates, however, are lenses of manganese oxide, which are considered indicative of deep-sea origin. Toward the end of the Mesozoic (very prob-

ably during the Cretaceous) the second major diastrophism occurred, another revolution and dynamism with both subsidence and uplift. It was during this time that the Jurassic cherts and slates referred to were metamorphosed.

On account of this revolution a great land area, archipelagic in character, appeared on the present site of the Philippine Archipelago. A great basal conglomerate, represented by the Agno beds of Luzon, above the older slates and schists, indicates an unconformity and a long period of erosion. Erosion and deposition continued until the close of the Oligocene. The later deposition was in shallow water and the Philippine coal beds were laid down at this time. Closely following the deposition of coal beds in Oligocene time, beginning early in the Miocene and continuing until the close of the period, was another period of major diastrophism, the well-known "Miocene Revolution," which greatly folded the sandstones, the shales, and the coal beds. There was also much faulting. Concomitant with this folding and faulting there were intrusions and extrusions of andesitic and basaltic lavas, followed by ore deposition. This was the third period of ore deposition in the Archipelago. The volcanic activity has continued with more or less interruption through the Pliocene to the present. In the Pliocene the activity was manifested in the deposition of thick beds of volcanic ashes, now consolidated into tuff, while within Recent time volcanic cones have been built up by fragmental ejecta.

Succeeding the "Miocene Revolution" was a period of erosion, deposition, and subsidence. On the submerged portions conditions were favorable for the growth of corals, and a thick accumulation of coralline limestones with some sandstones was deposited during the Pliocene. Volcanic agglomerates and fanglomerates were also present in this period. Then followed a general uplift, which has continued up to the present time. Uplifting was not the only process, as subsidence occurred as well. This uplift is one of the major episodes in the geologic history of the Philippine Archipelago, as it represents a rise of about 1,500 meters since the Pliocene. The emergence of large areas during the Pleistocene was probably due in part to the withdrawal of the water to form the continental ice sheets. During the Recent there was submergence of land areas, probably due to deglaciation. Uplift was produced on account of differential crustal movements. These later land movements are indicated in the different parts of the Archipelago by drowned valleys,

elevated beaches, and reefs. The last episodes in the geologic history have been the building up of volcanic cones, reef building, and the work of streams and waves.

Summarizing the foregoing discussion, we note that practically all of the principal rock types are found in the Philippines. On a basement complex of Paleozoic rocks there are many thousand feet of Tertiary sediments, with some small outcrops of Mesozoic rocks. These are, in turn, partly covered with lavas of andesitic type and with great accumulations of more recent tuffs and coralline limestones. The Archipelago is not dominantly volcanic, although extinct and active volcanoes are scattered through the whole area.

A preliminary geologic map of the Philippine Islands, showing the different formations, is given as Plate 1.

The geologic column of the Philippine Islands is shown in Table 1.

TABLE 1.—*Geologic column of the Philippine Islands.*

Era.	System.	Period.	Formation.	Standard section.
Cenozoic.	Quaternary.	Pleistocene.		Elevated coral reefs and high level river deposits in many parts.
	Tertiary.	Pliocene.	Guadalupe. Malumbang.	Tuff beds in southwestern Luzon, with teeth of deer and sharks. Coralline limestone beds in Bondoc Peninsula, Tayabas, and Cebu.
		Miocene.	Santa Cruz. Alpaco.	Santa Cruz, Zambales, tuffaceous marl. Mount Alpaco, Cebu, tuff and sandy marl.
		Oligocene.	Vigo. Binangonan. Batan.	Sandstones and shales with oil seeps. Limestones with large Lepidocyclinas. Shales and grit with coal, with *Vicarya callosa*.
		Eocene.	Agno.	Conglomerate beds of the Agno River.
Mesozoic.	Jurassic.		Baruyen.	Radiolarian cherts with *Cenosphaera* and *Dictyomitra*.

A BRIEF HISTORICAL SKETCH OF PHILIPPINE MINING OPERATIONS PRIOR TO AMERICAN OCCUPATION

By ANTONIO D. ALVIR

For a long time before the coming of the Spaniards, Filipinos were already washing gold from the streams, mining copper ore and smelting it in crude furnaces, and probably also mining and smelting iron ore. Because of the similarity of the crude native furnaces and those of the Chinese, it is thought that the Chinese taught the Filipinos the rudiments of mining and smelting. Chinese writings of about the third century A. D. are said to report gold the chief product of Luzon.[1] Due to the hostility of the mountain tribes and their unwillingness to disclose the whereabouts of their deposits, very little was done in the development of the mineral resources in the early days of Spanish occupation. Later, rich deposits of gold, copper, iron, and coal became generally known and mining companies were formed, but all were more or less unsuccessful. The Spaniards essayed to develop the Philippine mineral resources along modern and scientific lines and, although mining during Spanish times never became profitable, the knowledge concerning our economic deposits was greatly enhanced through their studies and developments, and by their mistakes and experiences the present industry has greatly profited.

The history of mining prior to American occupation is essentially the history of gold, coal, iron, and copper mining, and these activities will be briefly reviewed.

GOLD

Gold is present in most Philippine rivers and the natives have obtained it from time immemorial by simple washing. Placer mining was probably the earliest mining operation.

It is claimed [2] that the remains of old mine workings in Aroroy, Masbate, are very old Chinese, because pieces of Chinese pottery, from earlier than the Ming Dynasty, were found near the old

[1] 21st Ann. Rept. U. S. G. S. (1901) 90.

[2] Smith, W. D., Geology and Mineral Resources of the Philippine Islands, Bur. Sci. Publ. 19 (1924) 468.

tunnels and open cuts. It is probable therefore that lode mining was practiced long before Spanish times and that the Chinese were influential in early mining. Chinese history tells us that as early as the third century A. D., Luzon exported gold to China. Morga, a Spanish historian, says that before Magellan's arrival gold figured conspicuously among Philippine exports to China.

Upon the finding of a golden image weighing about 1,790 grams in a tributary of Agusan River in Mindanao, Prof. H. Otley Beyer[3] concluded that the image was Javanese, of the Ngandjuk period and, therefore, that Javanese miners probably mined gold in Mindanao as early as 1350.

The most important gold mining districts of to-day are the same as those of early times. Morga, writing about three hundred years ago, told of the rich gold deposits of northern Luzon which were zealously guarded by the "savages." Blair and Robertson speak of the knowledge of gold in Mindanao, Masbate, and Paracale as far back as 1544. Hernando Riquel, in 1574, wrote very enthusiastically of the rich gold mines of Luzon, and probably had in mind the Paracale-Mambulao district in Camarines Norte.

It is reasonably safe to say that gold was panned in the Paracale-Mambulao district before the coming of the Spaniards. Long before the other gold districts were known to the conquerors, Paracale and Mambulao were the scene of much mining activity. The washing was done in wooden pans called *bateas*, shaped like a wide shallow cone. During the last years of Spanish rule, a native dipper dredge came into use with a capacity of 2 to 3 cubic meters a day. This remained in use until 1908.

In 1626, Don Diego de Espina discovered a vein called the *vena grande* or *vena real* on Mount Calacot near Mambulao. About 1848 the Ancla de Oro company was established to exploit the vena real. A drainage tunnel, the portal of which is still well preserved, was driven. This company failed after long and active efforts to win the values from the refractory ores encountered, although some of the ores were free-milling. The ore was first broken up in a mortar and pestle. The fine grinding was done in the *arrastre,* which the Spaniards introduced from Mexico, and of which there were about a score in this district. Then the finely ground ore was washed in the wooden

[3] Smith, W. D., loc. cit.

bateas and, if the ore was free-milling, the values could be recovered.

In 1892, the Philippine Mineral Syndicate, an English company, entered the field with large plans and considerable capital. The stamp mill was then introduced into the Philippines. With the Insurrection in 1896, operations ceased before production had been reached.

In 1894 the Spanish government prohibited Filipinos from engaging in the mining industry, and thus activities declined.

A German company, La Candelaria, was active in this district at about the time of American occupation, but failed to accomplish anything in that unsettled period.

The total amount of gold produced in this district prior to American sovereignty is not known. Montero y Vidal [4] claims that the production from the placer mines of Luzon did not fall below 100,000 pesos a year, in spite of the crude methods used. This figure includes production from the other placer deposits of Luzon, but none was as important as were those in the Paracale-Mambulao district. The price then was 22 pesos per tael, or 1.5 Spanish ounces.

Morga, writing in 1609, said that the production of gold in the Philippines was 200,000 dollars annually, and that nearly all of this output came from Paracale.

The other known gold localities of this period are Masbate, northern Mindanao, and Cebu. Reference has already been made to the old mine workings of Masbate. Caseri, an Italian who went around the world in 1695 to 1698, wrote of the rich gold mines of Masbate. Both placer and lode mining were in practice. In 1848, a newspaper in Manila published an article concerning the gold deposits of that island; but nothing has been found to indicate that the Spaniards exploited these ore deposits.

Surigao became known to the Spaniards much later than any of the other important districts, although the inhabitants of Misamis and Surigao had already been panning gold from the streams long ago. Sainz de Barranda made a report on the gold placers of Misamis in 1848. Centeno, Minard, and Abella were also familiar with these deposits as well as with those of Surigao.

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[4] El Archipielago Filipino y las islas Marianas, Carolinas y Palaos (1886) 51.

William Ashburner, a noted American mining engineer, examined the Surigao gold properties in 1883, but did not recommend the district to his principals. He learned that the inhabitants produced about 20,000 dollars worth of gold annually.

In 1871, on account of high assays of a gold and silver bearing lead ore, which came from Acsubing and Panoypoy, Cebu, a society called La Cebuana was formed to exploit the deposits; but there was very little ore, and the claims were soon abandoned. Ore of this quality is also found in Paracale and other places. Since it is not a free-milling ore, the old method of grinding and panning was unsuccessful.

In conclusion, we find that, in spite of all the efforts of the Spaniards, gold mining did not prosper very much if at all. They centered their activities in Camarines and failed. In other districts little or no exploitation was accomplished. The Government seems to have done all it could to promote the industry by special decrees and legislation but, unfortunately, to no avail.

COAL

It is not to be expected that our coal deposits were exploited by the Filipinos prior to Spanish rule, since they had no use for coal. Besides, it was not until 1827 that coal was discovered in the Philippine Islands.

It was in Cebu that coal was discovered by the Spaniards in 1827. In the year 1842 it was reported that steamboats were coming to the Philippines for the first time. Consequently, inquiries were made into our coal resources, especially those of Cebu. Ten years later the Danao coal district was discovered and reserved for the Government. In 1853 the first concession in Cebu was awarded, to Viña, Roxas y Compañía, who wanted to exploit the Guila-Guila coal deposits on Mananga River not far from the city of Cebu. A road was built from Guila-Guila to the coast before the amount of workable coal was ascertained. The company expended seventy to eighty thousand pesos, not including the convict labor loaned by the Government, only to find that faulting had displaced the coal so that it could not be traced. The company was then dissolved.

In 1859 Da. Margarita Roxas started operations at Uling and Viña at Alpaco. At Uling a tunnel was driven 649 meters into coal. Encouraged by successful steaming tests on some steamers, roads were built before a regular production could be

depended upon. Da. Margarita Roxas built a 15-kilometer road between Uling and Alpaco. However, it was found later that the coal was pyritic and did not store well, so the navy stopped using it. Since the navy was the only market, the mines failed.

Isaac Conui in 1871 solicited the Compostela coal deposits, and two years later applied for those of Danao River. A road was built from Cotcot to Dapdap in 1877. In 1890 a company, Sociedad Nuevo Langrea, started actual work in the district. Tramways were built from Danao to Camansi and from Compostela to Mount Licos in 1895. In 1898 Enrique Spitz consolidated all these concessions under his name and the Sociedad Nuevo Langrea passed out of existence.

In 1842 in Batan Island, Albay Province, Governor Velarde of Albay made the first open cut in coal and for the first time coal was shipped from Calanaga Bay to Manila. During the following fifty years development work in that district consisted merely in location and relocation of claims. In 1893 claims were taken up by Minas de Batan, a company owned by the Gil brothers. This company did not begin actual operations until 1899.

In 1874 the La Paz Company was organized to exploit certain coal deposits near the barrio of Bacon, San Esteban, Sorsogon. According to Centeno, six shafts were dug varying from 22 to 34 meters in depth. Five galleries and crosscuts were driven, aggregating 66 meters in length. Marty noted that there were 130 meters of gallery at a level of 11 meters below the surface and 188 meters at 24 meters level. No faults were encountered. After producing a little coal, this company failed because of lack of capital.

In 1887 work was started in Cataingan, at the lower end of the eastern prong of Masbate Island. There was no systematic mining; coal was simply obtained from open cuts, located in a haphazard manner. The work continued until 1895, when the total production amounted to 625 tons.

In Mindanao coal was discovered in the Sibuguey district in 1855. However, no development was done prior to American occupation.

IRON

Next to gold iron was the earliest metal to be exploited in the Philippines. As early as 1664 native furnaces in Bulacan were in operation and producing agricultural implements.

The deposits in the district of Morong (now Rizal) were first exploited by the Spaniards. After a time, those of San Miguel de Mayumo and Angat, Bulacan Province, were worked for the manufacture of plowpoints, plowshares, bolos, or knives, and kitchen utensils. At the beginning of the nineteenth century an attempt was made to establish a large smelting plant, with large furnaces and corresponding machinery; but, owing to the great difficulty of transportation, the enterprise failed even before work on the deposits had commenced.

Other deposits known in 1883, as recorded by Abella, [5] but not exploited, were those of Paracale (Mambulao), Camarines Norte, Caraballo Mountains in Luzon, Cebu, and other places.

The earliest available record regarding iron mining bears the date 1781. It is a letter ordering that all possible assistance be given to Padre Belli in the operation of his iron mine in Angat, Bulacan. The next is a petition by Santiago Hison that he be declared discoverer of the iron-ore deposits in Sapang Bacal, which was granted in 1815. These deposits passed through many hands until, finally, Da. Maria Alteza Fernando acquired them.

The iron-ore deposits of Bulacan were being worked in conjunction with the crude native furnaces, for the manufacture of plowshares and plowpoints, when the Americans landed in the Philippines.

COPPER

In an official communication dated 1838, Don Pascual Enrile wrote that for several centuries utensils were made by the Igorrotes of the copper obtained from the ore deposits of Mankayan, in what is now Mountain Province. Explorers were sent to examine the deposits. The samples obtained ran high in assay. The Inspeccion of 1838 was then created and the mining law of 1846 enacted. In 1850, Don Antonio Hernandez, with a military column for protection against the hostile Igorrotes, led an expedition to explore these copper deposits.

It is estimated that, between 1840 and 1855, 600,000 pounds of copper were produced, valued at about 117,000 pesos.

Don Tomás de Balbás y Castro also sent an expedition in 1855. The following year he applied for demarcation of properties. He owned four *pertenencias*, or claims, and had one hundred twenty Chinese coolies working on them. He had

[5] Ligera reseña de la minería de las Islas Filipinas (1883).

agreed to pay 500 pesos to the Igorrotes for their holdings. In the same year the Cantabro-Filipino Company was formed and it intrusted the operation of the mines to Don José María Santos, an eminent Spanish mining engineer who wrote a report on the copper mines.[6]

The year 1860 marked the first actual production of the Cantabro Filipino.

Production of the Cantabro-Filipino Company.

Year.	Tons of ore.	Output, pounds of copper.
1860–1861	1,941	25
1862	1,800	
1863	2,200	
1864	2,500	
1866	1,254	234,807
Total, 1860–1874		2,500,000

Work was suspended in 1875, due to the death of Santos, and never was resumed. This was the end of the Cantabro-Filipino Company. Since then there were only the crude operations of the Chinese and the Igorrotes until 1900, when claims were again located and development was resumed.

NONMETALS

Abella, in 1890, in his description of Panay Island, was the first to mention gas or petroleum in the geologic literature of the Philippines. He said that in Cebu and Panay some shales were found from which petroleum could be distilled. He also mentions a combustible gas in Quinauilian Creek in Panay.

In 1896, Smith, Bell and Company drilled two wells near Toledo, Cebu, but the revolution broke out and the drillers, who were Americans, were driven out. The wells reached a depth of 244 and 344 meters, respectively. Petroleum was encountered and a small quantity produced. The district has remained idle ever since.

Sulphur was extracted at Biliran Island and at Burauen, both in Leyte Province, and perhaps in other places, as volcanoes and solfataras occur all the way from Mount Cagua in northern Luzon to Mount Apo in Mindanao.

[6] Informe sobre las minas de cobre de las rancherías de Mancayan; etc. (1862).

The people of Mountain Province produced a certain amount of salt of a poor grade by evaporating water from the carbonated brackish springs in Bontoc and Ifugao and Nueva Vizcaya. Salt making by the evaporation of sea water is an old industry among the Filipinos, and Spanish writers referred to it as an occupation over three hundred years old. It is very probable that, ever since the Philippine Islands were inhabited, salt making was practiced by the people.

Rock quarries were located near and around Manila and other places. Basalt for road metal was obtained from Morong, Rizal. Adobe stone, or volcanic tuff, was quarried in Mariquina, San Mateo, and Guadalupe in Rizal, Meycauayan in Bulacan, and other places. The principal stone used in the construction of churches and buildings was volcanic tuff, volcanic rock and, in certain places along the coast, coralline limestone. Marble was quarried in Romblon and used in Manila for making fonts and similar articles. In San Pedro Macati there was a brick factory, La Olimpia, which utilized the clays found there. Kaolin was obtained from Mount Maquiling and was used in making water paints.

PHILIPPINE MINING FROM AMERICAN OCCUPATION TO THE PRESENT

By LEOPOLDO A. FAUSTINO

The Royal Decree of 1867, "Concerning the Control of the Mining Industry in the Philippines," was the general mining law in force in the Islands when the Americans came. The Mining Bureau was organized by General Order No. 31 of the Military Governor, on March 10, 1900, to take over the work of the Spanish Inspección General de Minas. On July 1, 1902, the Congress of the United States enacted a new mining law. Act 915 of the Philippine Commission provided for the transfer of the administration of mining grants and claims instituted prior to April 11, 1899, from the Mining Bureau to the Bureau of Public Lands, and Act 916 of the same body prescribed the functions of the Mining Bureau, which are essentially the furtherance of the development of the mineral industry of the Philippine Islands. In 1905 the Mining Bureau and the Bureau of Government Laboratories were united under the present name, Bureau of Science, and the Mining Bureau became the Division of Geology and Mines of the Bureau of Science.

Shortly after the beginning of American occupation, mining development was carried on in Benguet (now a subprovince of Mountain Province), Bulacan, Tayabas, Camarines Norte, Albay, Masbate, Cebu, and Surigao Provinces. Gold was the principal object of prospecting and development in Benguet, Camarines Norte, Masbate, and Surigao Provinces. In Bulacan Province the iron deposits were worked to supply ore to the native furnaces. Location of petroleum claims was active in Tayabas Province. Coal prospecting and development were carried on in Batan Island, Albay, and Cebu.

The first statistics of mineral production in the Philippine Islands were tabulated for 1907, and the extent of the mining industry is shown in Table 1.

TABLE 1.—*Mineral production of the Philippine Islands for 1907.*

Product.	Quantity.	Value.
Metallic:		*Pesos.*
Cast iron.....metric tons	132	19,536
Gold.....fine grams	141,212	187,647
Silver.....do	2,582	110
Nonmetallic:		
Coal.....tons of 1,016 kg	4,116	26,799
Total.....		234,092

In general, it may be said that the minerals that were produced during the Spanish régime have continued to be produced without change to the present time, and the mining industry to-day centers practically around the same districts as it did during Spanish occupation. The production of gold has steadily increased, owing to better methods of mining and the introduction of modern methods of extraction. Systematic mining replaced plain digging, and modern stamp and cyanide mills took the place of *arrastres*. There has been little change, if any, in the operation of the native iron furnaces and there has been but a very gradual increase in the production of plowshares and plowpoints. The Surigao iron deposit was discovered in 1912 and reserved for the public purposes of the Philippine Government in 1915. More copper was produced during the Spanish régime than at any time since. The chromite deposit in Zambales was discovered in 1925 and reserved the latter part of that year for the public purposes of the United States Government.

There has been a large increase in the production of coal. Methods of mining coal have improved and more tramways, aërial cables, and loading towers have been constructed. The best-known oil district was tested by drilling. Cement was first produced in 1915, and the production of materials used for construction has increased by leaps and bounds.

The successive stages in the development of the mining industry since American occupation will be considered for the more important minerals.

GOLD AND SILVER

TABLE 2.—*Production of gold and silver in the Philippine Islands for 1907, 1910, 1915, 1920, and 1925.*

Year.	Gold.		Silver.	
	Fine grams.	Pesos.	Fine grams.	Pesos.
1907	141,212	187,647	2,582	110
1910	232,316	308,860	55,987	1,944
1915	1,981,587	2,633,528	486,917	15,665
1920	1,920,753	2,424,606	307,343	19,261
1925	2,928,003	3,891,979	2,132,521	92,120

The first sign of activity in the gold and silver industry was the erection of a 3-stamp mill in Benguet Province, in 1903. It will be remembered that the first stamp mill was brought

into the Philippine Islands by a British corporation in the Mambulao-Paracale district, about 1892. Several stamp mills were soon built in Benguet and in Masbate, and in 1907 there were three small stamp mills operating in Benguet and two in Masbate. These earlier mills were designed essentially for the amalgamation process, but later the cyanide method was introduced. In the Mambulao-Paracale district, in Camarines Norte, a New Zealand dredge was operating as early as 1906.

All the Philippine gold and silver districts have had a checkered history. The Benguet district in Mountain Province has been the scene of active prospecting and development ever since the Americans came, but only during the years 1908 to 1911 and since 1915 have successful mining and milling operations been carried on by organized companies. In 1909 this district was visited by a destructive flood which tore away the entire cyanide plant of the Benguet Consolidated Mining Company and crippled the entire district. In 1911 the Benguet Consolidated was again destroyed by flood. It was not until 1914, when the plant was rehabilitated, that the company began to function consistently. With the exception of the milling operations of a small 3-stamp mill, there was practically no production in this district from 1911 to 1915. Since 1915 the Benguet Consolidated Company has been operating successfully. With the exception of this company, all the mills erected in Baguio have failed. At the present time there are four companies operating in the district. The Benguet Consolidated Mining Company is producing; the others are doing prospecting and development work.

A little farther to the north is the Suyoc district, near Mankayan, also in Mountain Province, where prospectors have panned considerable gold, notably in the Palidan Slide. At one time Mr. Gillies treated the ore in an arrastre. In Binalonan, Pangasinan, a small stamp mill has been operating intermittently for some years.

The development of the Masbate district during American occupation may be said to have begun at the time when the United States Army was first stationed in Aroroy, Masbate. The first attempt at gold production was by dredging on Guinobatan and Lanang Rivers in 1904 and 1905. Two dredges were installed, but both failed. One was destroyed by a typhoon, the other was dismantled and transferred to the Paracale district. In 1907 a small stamp mill was erected on Guinobatan River, but its operations were short-lived. The district did not

begin steady production until 1911, when the Colorado mill was completed. In 1913 the Syndicate and Keystone mills were erected. During 1912 and 1913 the Masbate district attained its greatest development. Then followed a series of setbacks. Due to impoverishment of ore the Keystone mill closed down in 1916, and for similar reasons the Colorado mill stopped operations in 1922. At the present time there are two operating mines in the district, the Syndicate and the Panique. The latter started milling operations in 1923.

Dredging has always been the main operation in the Mambulao-Paracale district. When the Americans came small but fairly effective dipper dredges made of bamboo were in operation. These were gradually replaced by modern dredges employing American, Australian, and New Zealand practices.

In 1906 only one dredge was operating. The number gradually increased and in 1915, when the district was at its greatest development, there were nine dredges operating in Paracale and Malaguit Rivers. The first great disaster came in 1917, when the Gumaus dredge sank in Gumaus Bay during a destructive typhoon. The ground values had begun to depreciate and, one by one, the dredges were dismantled, until at the present time only one lone dredge is operating.

The lode properties in this district are near Mambulao, but there has never been any very successful quartz mining here. Several stamp mills were built, but their operations were unsuccessful.

Northern Mindanao has been less active than any of the districts mentioned in the preceding pages. The placers of Iponan and Cagayan have been little worked. The Surigao Mining Company did some sluicing in the Cansuran district in northern Surigao in 1911, and the Cansuran Company began large-scale hydraulic operations with monitors in the same district in 1914 and 1915, but both operations were short-lived and unsuccessful. This district came into prominence again when the Lianga Mines, Limited, started dredging operations along the upper Hinatuan River near Lianga in Surigao Province on the east coast of Mindanao. The Lianga dredge is still operating.

There are other districts where the search for gold has been active; namely, Binaybay River, Mindoro, and near Peñaranda, Nueva Ecija, but only the activities in Umirey River, Tayabas Province, on the east coast of Luzon, will be mentioned. In 1912 a small sluicing plant was installed on the ground below the cataracts of Umirey River, but this was swept away by a

freshet and everything was lost, including the gold in the sluice boxes, estimated to be worth about 10,000 pesos. Near the mouth another dredge was installed some years ago by the Umirey Gold, Limited, but its operations were unsuccessful and the dredge was dismantled and moved to the Lianga district in Mindanao.

IRON

TABLE 3.—*Production of cast iron in the Philippine Islands for 1907, 1910, 1915, 1920, and 1925.*

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Metric tons.	*Pesos.*		*Metric tons.*	*Pesos.*
1907	132	19,536	1920	87	40,191
1910	50	20,023	1925	398	62,590
1915	96	22,694			

The Bulacan iron-ore deposits have continued to supply the native furnaces with enough ore to manufacture a small quantity of plowshares and plowpoints. The method used at present in producing iron is essentially the same as that used before American occupation, although several attempts have been made at increased production, particularly during the World War, when there was shortage of gray scrap and pig iron. In 1917 a Japanese concern leased the property on Calambayungan Island near Mambulao, Camarines Norte Province, and started to mine and ship the ore to Japan. The company discontinued operations in 1919. In 1920 a 9-ton furnace was erected at Limay, Bataan Province, to treat briquetted magnetite sands, but operation was unsuccessful.

Probably the most important event in the history of iron in the Philippines was the discovery of a large deposit of lateritic iron ore in Surigao Province, about 1912. The deposit was reserved by the Philippine Government in 1915, and the National Iron Company was organized to exploit the deposit, but nothing has been done up to the present time.

OTHER METALLIC MINERALS

The activity in the copper districts has been merely prospecting and development. A few important discoveries have been made, near San Marcelino, Zambales, in Marinduque, and northern Mindanao, but there has never been any commercial production. The Mankayan deposit in Mountain Province has been the scene of active development for some years. A small amount

of copper was smelted by Igorrotes in this district in 1910 and 1911. The small production of copper during Spanish days was much greater than the amount produced during American occupation.

In 1916, during the World War, 3,000 tons of manganese ore were mined in Ilocos Norte Province and shipped to Japan. In 1918, 650 tons of ore were mined, but never sold.

A small amount of platinum was produced for the first time in 1922 as a by-product of gold-dredging operations in Lianga district, Surigao Province. Platinum has been known for a long time near Peñaranda, Nueva Ecija; in Mariquina River, Rizal; and in Agusan Valley and Misamis, Mindanao; but there was no production prior to 1922.

In later years the most important event in the history of the mineral industry was the discovery of a large chromite deposit in Zambales Province in 1925 by Mr. V. Elicaño, chief of the division of geology and mines. This deposit has been reserved by executive order of the President of the United States, dated September 24, 1925, for the public purposes of the United States.

COAL

TABLE 4.—*Production of coal in the Philippine Islands for 1907, 1910, 1915, 1920, and 1925.*

Year.	Quantity, tons of 1,016 kilograms.	Value.	Year.	Quantity, tons of 1,016 kilograms.	Value.
		Pesos.			*Pesos.*
1907	4,116	26,799	1920	57,960	1,452,200
1910	28,609	176,255	1925	47,912	618,822
1915	None	None			

Batan Island, Albay Province, showed the first signs of active coal mining under the American régime. In 1904 the United States Army began exploration and development, supplemented by drilling, at its western end. The enterprise was at its greatest development in 1909, when approximately 2,500 meters of galleries were opened up. It was not considered much of a success, however, and the mines and workings were abandoned in 1910. In July, 1921, the military authorities turned the property over to the Civil Government and it was taken up by lease December 15, 1921. The Liguan Coal Mines, Incorporated, holds the lease at the present time.

At the eastern end of the island the East Batan Coal Company started operations in 1905, and also attained its maximum devel-

opment in 1909, when its workings consisted of 6,096 meters of galleries with a main entry of 295 meters, but in 1911 the mines were flooded and shortly afterward the company went into the hands of a receiver. In 1917 the Philippine Coal Mining Company started operations on the property next to that of the East Batan Coal Company. This company produced between 300 and 500 tons a day during the early part of 1921 but, toward the latter part of the year, it became bankrupt and went into the hands of a receiver. The property fell into the hands of the Philippine National Bank, which also has acquired another lease in a nearby area. The other operator in this district is A. U. Betts who has opened up new workings near the barrio of Dapdap.

The old Minas de Batan on the northeastern portion of the island near Calanaga Bay were worked by a Spanish company during the early days of American occupation. Considerable money was spent but the production was small and the company finally went bankrupt. Japanese miners next took up the property, but their methods were wasteful and the production was small. In 1923 the Calanaga Coal Mining Company did some development work in the area and had a small production. In 1925 Strittmatter and Karolchuck next took up the property, but there has been little production. J. E. Barker sunk several shafts and drove several tunnels at Caracaran, south of Calanaga Bay, and was able to produce a small amount.

Exploration work in Cebu started about 1907 and 1908, when two companies were engaged in development work, the Insular Coal Company in the Mount Licos and Camansi region and a New York syndicate in the Cajumayjumayan valley. In 1912 Camansi was visited by a severe typhoon which destroyed part of the railway and buildings. It was not until 1917 that active operations were resumed in this region, by the Danao Coal Mining Syndicate in Camansi and other places and by the National Coal Company in Mount Licos. The Danao Coal Mining Syndicate changed hands in 1922. At the present time this company is the only one operating in the entire Cebu field. The National Coal Company started active exploration work in 1918, when it acquired by lease the Mount Licos property. Several tunnels were driven and a 4-kilometer aërial cable tramway was constructed. The company abandoned its mines and workings recently, the reason assigned being lack of minable coal.

In the Mount Uling district exploration work was started in 1913, but there was no commercial production until 1917, when

the Uling-Naga Coal Company, formerly Bryan and Landon, began producing coal. This company was able to maintain a steady and increased production until August, 1925, when it suspended operations for lack of funds. The Cebu Portland Cement Company started diamond drilling operations in the Mount Uling district in 1925 but, after having drilled three holes, relinquished the project for lack of funds.

The Cebu coal field attained its maximum development in 1920, when the Philippines was experiencing abnormal postwar coal prices. During that year all the known coal localities of Cebu were worked, both by regular and by *paquiao,* or gopher, methods.

In 1907 some prospecting work was carried on in the Sibuguey (Malangas) district, Mindanao. The National Coal Company operations did not start until the latter part of 1917. This company has had several places under exploration and development and has been able to maintain an existence until this time, although experiencing considerable difficulty in marketing its semianthracite production. A 12-kilometer railroad, a wharf, coal bunkers, and loading equipment have since been constructed. This district has been core-drilled, but the data obtained have never been interpreted. The company produces semianthracite coal of good quality, but this kind of coal does not find a ready market in the Philippines. The soft coal which it is able to produce comes in the main from gopher operations.

OTHER NONMETALLIC MINERALS

Drilling for petroleum was started in 1921, in Bondoc Peninsula, Tayabas, by the Richmond Petroleum Company, a subsidiary of the Standard Oil Company of California. Four test wells were drilled, the deepest 5,117 feet, but the results were all negative and the company discontinued drilling activities in July, 1924.

Rock asphalt was discovered in Leyte in 1913 by a Filipino forest ranger, but commercial exploitation did not begin until the latter part of 1918. A small amount was produced during the years 1919 to 1921, the greater portion of which was used in the surfacing of roads.

Small amounts of sulphur and asbestos were produced in 1918 and 1919. Since the erection of the cement plant in Cebu in 1923 a small quantity of gypsum has been produced. Increased demand for fertilizers started the development and exploitation of the guano deposits. The sugar industry has

increased the demand for lime, which is used in the clarification process.

The increase in the production of materials used for construction is very marked due in the main to the building of first-class roads, concrete buildings, irrigation dams, and other public improvements. The production of sand and gravel has exceeded the one-million-peso mark. Cement was produced from 1915 to 1919, and from 1923 to the present, with good prospects of increased production.

IRON AND STEEL METALS

By RAMON F. ABARQUEZ

Iron.—Iron is produced at present in only one locality and that is the Angat district in Bulacan Province, where native furnaces are in operation. The iron deposit on Calambayungan Island, near Mambulao, Camarines Norte Province, was abandoned in 1919, as the Japanese operating it found it unprofitable to mine the ore and ship it to Japan. The Surigao iron deposit on the eastern part of Surigao Peninsula, reserved by executive order in 1915 from mineral location, has not been touched up to the present time. Magnetite sand has been known to exist in workable quantities along Manila Bay near Mariveles, Bataan Province.

The Bulacan iron-ore region lies in the foothills of the westernmost range of the Eastern Cordillera, along a north-south line east of the towns of Angat and San Miguel, Bulacan Province. Discontinuous exposures are found over a total length of 15 kilometers; the southernmost outcrop is about 8 kilometers northeast of Angat. The ore consists essentially of magnetite and hematite, in intimate mixture but in varying proportions. The magnetites are soft and a considerable portion is objectionably fine. Quartz is the predominant gangue mineral. Pyrite occurs in the ore in varying proportions. The average ore carries about 60 per cent iron. The deposit is estimated to contain between 1,000,000 and 2,000,000 metric tons of ore.

The Calambayungan iron deposit is situated on the western part of Calambayungan Island, and on the adjacent mainland over an undetermined distance. This island (about 1,100 meters, or 0.7 mile, in length) is in Mambulao Bay on the north coast of Camarines Norte Province. By combined railroad and steamship routes the town of Mambulao, the nearest port of the iron deposit, is a little more than 185 kilometers (115 miles) from Manila. Blocks of different sizes of black ores, angular in form and with pitted, irregular surfaces, mark the outcrops of the deposit. The ore, moderately soft and porous, consists of almost pure, massive or granular hematite with traces of magnetite, and carries an average of about 60 per cent iron.

The estimated ore content of the deposit is between 1,000,000 and 3,000,000 metric tons.

The reservation which was made to cover the Surigao iron ores consists of an almost triangular area in the eastern part of northern Surigao, bounded on the west by a north-south line through the town of Giganquit, on the south by an east-west line through the town of Cantilla, and on the east and northeast by the seacoast.

The Surigao iron ore is of a lateritic nature. The ore is principally ferruginous clay, containing an abundance of small round pellets of hydrous iron oxides. The ore is soft, spongy, and mealy. The average ore contains about 52 per cent of iron and is free from objectionable impurities. The deposit is estimated to contain about 500,000,000 metric tons of ore.

At the present time the only source of iron in the Philippines is from the operations of native furnaces in Bulacan. The present Angat practice consists essentially of dumping carefully selected ore into a crude fire-clay furnace with charcoal, but without flux. A very unsatisfactory blast of air is produced by means of a large, hollowed tree trunk, containing a piston operated by one or more men. The metal and slag run out of the same opening, the slag first, followed by the metal. The latter is then poured into small fireclay molds for casting plowshares and plowpoints.

With a view to familiarize the reader with the present Angat practice,[1] the following paragraphs are quoted:

> The furnaces are cylindrical stacks from 2 to 2.5 meters in height and about 1.5 meters in exterior diameter. The upper part of the stack, to a depth of 1.75 meters, is hollow and constitutes the smelting crucible, which is shaped like an inverted truncated cone, circular at the top of the furnace with a diameter of about 1 meter, and elliptical at the bottom giving a section of a truncated cone with about 0.5 and 0.2 meter as major and minor axes, respectively. A rectangular runner, about 12 centimeters deep and 13 centimeters wide, pierces the bottom of the crucible from front to back of the furnace. The back end of the runner admits a single tubular clay tuyere, which is connected with the blowing apparatus and through which the blast enters the furnace. The front end of the runner, which is placed a little lower than the rear, serves as a tap-hole for both iron and slag. A block of quartz-sandstone, locally called *batong-buga*, is set in the wall of the crucible over the tap-hole just where the blast, entering through the tuyere from the opposite side, will impinge upon it. The walls of the furnace are soft-burned brick

[1] V. Elicaño, A. S. Argüelles, and Warren D. Smith, Iron smelting in the Philippines, The Mineral Resources of the Philippine Islands for the years 1919 and 1920 (1922) 41–43.

made of clay and set in a mortar of the same clay, which is the residual resulting from the decomposition of the granite found in the region. The sides of the crucible and runner are lined with a mixture of clay and charcoal powder.

The blowing apparatus, or *juncoy*, is a hollow log 35 centimeters in interior diameter and 3.5 meters long; it is fitted with a wooden piston which is edged with soft chicken feathers to prevent leakage of air around it. The piston rod is long enough to permit a full stroke when worked back and forth by hand. The blower is double acting, wooden tubes conducting the blast from valves at both ends of the displacement chamber to the tuyere. In operation the blower lies almost horizontal, one end being raised slightly from the floor to facilitate the work of the operator.

The molds (*hormas*), used for casting the plowpoints and plowshares, are made of clay reënforced by rattan or wire. Each mold consists of a base, which is fixed rigidly to a frame, or rack, and a removable cover, which is made securely fast to the base by a stick placed across the top of the molds with both ends tied to the rack. For convenience in pouring, one end of the rack is raised so that the molds are inclined at an angle of about forty degrees.

The fuel used in smelting is charcoal, usually burned near the smelting plant. A charcoal kiln, or an *inglesa*, as it is locally known, is a rectangular inclosure, the walls of which are made of bamboo poles; it is about 14 meters long, 4.5 meters wide, and 4.5 meters high. The logs for charcoal are cut into lengths one meter shorter than the width of the kiln, and are corded up inside the kiln, leaving half a meter space between the pile and the bamboo walls. Openings which run longitudinally along the floor of the kiln and up one end of the pile are provided, for maintaining a draft. The space around the pile inside the walls is filled with fine charcoal waste, and a cover of the same material is spread over the top. The fire is started at the lower end and gradually burns through the kiln, being retarded by the smothering effect of the charcoal-cover. It requires anywhere from fifteen to thirty days to burn a kiln of 140 cubic meters of charcoal. The charcoal is obtained in unusually large pieces, and is hard and strong.

To "blow in" a furnace, a slow fire is started in the crucible and allowed to burn for several hours; then charcoal is added until the crucible is filled and a light blast is applied. About twenty-four hours after the fire is kindled the blast is increased, and a small quantity of ore, together with more charcoal, is charged at the top of the furnace. Increasingly larger charges are added at intervals until the operation is normal and the furnace is in full blast. Afterwards ore and charcoal are charged together at intervals of from one to five hours, depending on the rate at which the iron comes down. The average charge consists of 43 kilograms of charcoal and 25 kilograms of ore. The ore is broken into pieces with a maximum diameter of about 2 centimeters. When the furnace is working normally, iron is tapped off every three or four hours.

As no flux is added to the charges, the clay lining of the crucible is quickly attacked and eaten away by the charcoal ash, so the smelting continues only as long as the furnace works well or until no more iron can be brought down—ordinarily for a period of from twelve to fifteen

days. When siliceous ores are smelted, the life of a furnace is extended to more than twenty-five days. The average capacity of the furnace is from 200 to 400 kilograms of metallic iron per day, all of which is made into plowpoints and plowshares. The castings produced are of a uniformly white, fine-grained iron, which is low in silicon, extraordinarily hard, and contains very little graphitic carbon. This should be expected with a furnace of such a short smelting column and with such a blowing equipment, capable only of producing comparatively low temperature.

All the iron produced in the Philippines is used in the manufacture of agricultural implements, such as plowpoints and plowshares. The total production of cast iron in 1924 was 273 metric tons, valued at 55,213 pesos, and in 1925 it amounted to 398 metric tons, valued at 62,590 pesos.

TABLE 1.—*Philippine cast-iron production from 1920 to 1925.*

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Metric tons.	*Pesos.*		*Metric tons.*	*Pesos.*
1920	87	40,191	1923	269	49,276
1921	174	39,225	1924	273	55,213
1922	156	30,611	1925	398	62,590

The iron and steel needs of the different industries in the Philippine Islands are supplied by importation from abroad, which in 1924 amounted to 24,094,119 pesos and in 1925 to 27,919,939 pesos. Tables 2 and 3, taken from the Annual Reports of the Insular Collector of Customs, show the quantity and value of iron products imported into the Philippine Islands, with the countries of origin.

TABLE 2.—*Iron and steel imported into the Philippine Islands.*

Article.	1924		1925	
	kg.	*Pesos.*	*kg.*	*Pesos.*
Pig iron	1,660,768	84,766	2,804,251	153,019
Bar iron	56,780	8,405	173,948	22,726
Bars or rods of steel	10,394,933	1,066,048	10,183,497	962,039
Railway track materials	13,294,512	1,413,334	10,851,872	1,172,277
Corrugated roofing	12,301,949	3,028,914	14,269,861	3,391,888
All other sheets and plates	8,074,294	1,642,165	9,672,649	1,878,618
Structural iron and steel	4,368,796	813,124	3,582,598	587,051
Wires and cables	5,033,051	944,546	5,830,568	1,058,801
Nails, spikes, and tacks	4,359,399	772,261	5,143,217	687,175
Needles, nuts, bolts, washers, and rivets.		335,494		385,463
Pipes and fittings	5,399,776	1,289,618	6,439,435	1,330,469
Tools		1,047,954		1,065,441
All other manufactures		11,647,490		15,224,972
Total		24,094,119		27,919,939

TABLE 3.—*Importation of iron and steel into the Philippine Islands, 1924 and 1925, by countries.*

Country.	1924	1925
	Pesos.	*Pesos.*
United States	18,701,669	21,264,889
Hawaii	1,456,953	1,206,586
Great Britain	1,280,256	1,037,108
Belgium	253,818	653,653
Germany	1,132,602	2,013,695
Sweden	108,023	218,713
China	70,850	151,850
Dutch East Indies	185,973	192,719
Japan	519,118	771,201
All other countries	384,857	409,525
Total	24,094,119	27,919,939

Manganese.—The deposits of manganese in the Philippine Islands are, as in many parts of the world, largely secondary concentration deposits and can be conveniently divided into manganese and manganiferous ore deposits. Manganese ores occur in Ilocos Norte, Masbate, Pangasinan, Bulacan, and Tarlac Provinces, chiefly as nodules and grains of psilomelane and pyrolusite, MnO_2, lying upon the surface of the ground. The manganiferous ores occur in Benguet Subprovince and Masbate Province, where manganese is found in association with gold-ore veins, mostly as manganiferous calcite and rarely as rhodochrosite.

There is little production of manganese at the present time. A very small amount of high-grade ore is sold to local foundries and battery factories. The Ilocos Norte deposit was worked in 1916 and 3,000 tons, valued at 30,000 pesos, were shipped to Japan. In 1918, 650 tons of ore, valued at 9,000 pesos, were mined also in Ilocos Norte Province but were never disposed of. All the better-known deposits of manganese have remained more or less idle, as the high freight rates make exportation prohibitive.

Chromium.—Concerning the chromite deposits of the Philippine Islands, the following information is taken from an unpublished report of Mr. V. Elicaño, chief of the division of geology and mines, Bureau of Science.

There is no production of chromite at the present time. Chromite deposits have been reported to occur in Antique, Mountain, and Zambales Provinces. The only deposit of importance so far known is that in Zambales Province, located about 25 kilometers

east of the town of Masinloc. This deposit has been reserved for "the public purposes of the United States" by Executive Order of the President of the United States, dated September 24, 1925, and made known by Proclamation of the Governor-General of the Philippine Islands, dated November 28, 1925. The area covered by the reservation is approximately 3 square kilometers. The deposit appears to be massive and is undoubtedly a segregation in the basic rock, pyroxenite, which incloses it. The deposit has been traced for a distance of about half a kilometer on the surface and is approximately 100 meters wide. It is estimated that several million tons of the mineral are available.

Samples taken at random show a chromic oxide (Cr_2O_3) content varying from 26 to 36 per cent. Complete analyses of two samples are given in Table 4.

TABLE 4.—*Analyses of two chromite ore samples from Zambales.*[a]

Corstituent.	No. 204.	No. 206.
	Per cent.	*Per cent.*
Chromic oxide (Cr_2O_3)	26.23	38.84
Ferrous oxide (FeO)	12.40	16.94
Ferric oxide (Fe_2O_3)	0.45	0.36
Aluminium oxide (Al_2O_3)	4.48	10.87
Silica (SiO_2)	18.48	10.53
Magnesium oxide (MgO)	22.80	13.67

[a] Analysis made in the division of general, inorganic, and physical chemistry, Bureau of Science.

Molybdenum.—Molybdenite (MoS_2), one of the two chief sources of molybdenum, has been reported to exist in small quantities as steel blue flakes and leaves in quartz veins, associated with other veins carrying copper sulphides, in the Loboo Mountains, Batangas Province. This mineral has also been noted in two other localities, Baguio District and Camarines Norte. No production is reported to date.

Tungsten.—Of the four minerals that may serve as important sources of tungsten, only wolframite, $(Fe,Mn)WO_4$, has been reported in the Philippine Islands. It is said to occur as heavy, black crystalline mineral in the hills east of Bugasong, Antique Province. Nothing definite is known regarding this occurrence.

Titanium.—Rutile (TiO_2, 60 per cent Ti when pure), at present one of the three chief sources of titanium, has been found to occur as microscopic crystals in some of the metamorphic

rocks from Ilocos Norte associated with actinolite, muscovite, and other minerals. No economically important deposit is known to date.

The two other important minerals of titanium are ilmenite and titaniferous magnetite. Ilmenite, (Mg, Fe) TiO_3, is found as small crystals more or less rounded, in black sand concentrates in many streams throughout the Archipelago. Up to the present no importance has been given to its occurrence. Titaniferous magnetite (aggregates of ilmenite and magnetite) has been found in some of the iron ores of Bulacan Province, but in limited quantity.

Zirconium.—Zircon ($ZrSiO_4$) has been found as minute crystals of brilliant white, almost metallic luster, in sands from Mindanao.

GOLD, SILVER, AND PLATINUM

By LEOPOLDO F. ABAD

Gold has been the most important mineral product in the Philippine Islands, and its production has always been taken as the barometer of the whole mining industry. The silver and platinum metals are not mined separately but are obtained with the extraction of the gold. The silver comes naturally alloyed with the gold, but the platinum in native form is recovered from the black sand concentrates obtained from the gold-dredge savings tables. Native silver and silver-bearing lead ores have been discovered in the Islands, but so far no commercial production of silver from these sources has been attempted. Native platinum has been found in minute flattened grains in the alluvial deposits of Nueva Ecija, Rizal, Agusan Valley, and Surigao, but the Lianga Mines, Limited, at Surigao is the only producer of this mineral at present.

The export of gold and silver bullion for 1924 and 1925, as estimated by the Bureau of Commerce and Industry, amounted to 3,473,864 pesos and 3,877,803 pesos, respectively. The production for the same years, according to the compiled reports in the Bureau of Science, amounted to 3,422,769 pesos in 1924 and to 3,984,799 pesos in 1925. The apparent discrepancy in these figures can be accounted for by the fact that small production by prospectors and by those panning the streams is not reported to the Bureau of Science, and a certain amount is used locally by jewelers.

By districts, the production of the precious metals will be seen in Table 1. It will be noted that the Mountain Province district leads all the others. The Surigao district, however, remains the only producer of platinum in the Philippines. The Mountain Province and Masbate districts produce gold on a large scale from the lode mines and the Camarines Norte and Surigao from the placer deposits by dredging.

THE MOUNTAIN PROVINCE DISTRICT

This district includes the old Baguio and Suyoc mineral districts. The first is located less than 8 kilometers east of the

City of Baguio and the second about 65 kilometers north. It lies about 270 kilometers north of Manila on the southern end of the Cordillera Central. The elevation varies from 900 to 1,500 meters above sea level.

The Suyoc district is reached by an 80-kilometer trail from Cervantes, which is connected by a third-class road to the coast town of Tagudin. Another approach to this region is via Baguio by an automobile road to Haight's Place and then by a cart trail of narrow tread. A first-class road connects the City of Baguio to the railroad station at Damortis.

The mineralized zone covers an area of over 100 square kilometers. The typical veins are fissures in andesite and in parts come in contact with diorite and sedimentaries. The veins vary in width from 1 meter to 50 meters, striking northeasterly and

TABLE 1.—*Gold, silver, and platinum production of the Philipine Islands in 1924 and 1925.*

District.	1924		1925	
	Fine grams.	Value.[a]	Fine grams.	Value.
		Pesos.		*Pesos.*
Gold:				
Mountain Province	1,809,768	2,405,819	2,226,623	2,959,685
Masbate	576,288	766,020	520,290	691,584
Camarines Norte	128,163	170,358	144,310	191,822
Surigao	7,404	9,842	36,780	48,888
Silver:				
Mountain Province	1,423,854	59,709	1,847,625	79,834
Masbate	232,228	10,059	254,261	10,992
Camarines Norte	23,030	910	24,190	1,036
Surigao	1,307	52	6,445	258
Platinum (crude):				
Surigao			137	700
Total		3,422,769		3,984,799

[a] One peso Philippine currency normally equals 50 cents United States currency.

southeasterly. The ore is quartz, which in places is mixed with calcite and manganese. The principal minerals are gold, silver, copper, lead, zinc, iron, and manganese. Telluride ores are also found. The ore is free-milling, and about 30 per cent of the gold could be amalgamated; but the Benguet Consolidated, at present the only large-scale producer in the district, treats its ore by the all-sliming and cyaniding method.

The Igorrotes still mine the gold in their primitive way by grinding and panning. Their production in 1925 is estimated at 50,000 pesos.

The Benguet Consolidated Mining Company.—For the last five years the Consolidated has been the greatest gold and silver producer in the Philippines. Its property is located in Antamok Valley, about 12 kilometers southeast of Baguio, and is reached by a good automobile road. The present operations started in September, 1915, and the company has continued to increase its production and its holdings in mineral lands, and has also made extensive additions to its milling plant until it now attains a daily capacity of 300 tons.

During the twenty years of its operation until the end of 1925, the company mined and treated about 488,658 tons of ore with an average value of 36 pesos per ton, at a saving of 91 per cent of the gold and silver content, or a total saving of 16,008,436 pesos.

From the company's Annual Reports for 1924 and 1925 the information in Table 2 was taken.

TABLE 2.—*Production of the Benguet Consolidated Mining Company.*

	1924	1925
Ore treated.....tons	89,621	92,700
Gross value of gold and silver produced.....pesos	2,394,998	2,927,469
Dividends paid.....do	1,100,000	1,200,000

The ore reserves at the end of December, 1925, are estimated as follows:

	Pesos.
Positive ore—exposed on four sides—53,897 tons	1,840,747.16
Probable ore—exposed on at least one side—29,470 tons	802,460.00
Total tonnage, 83,367 tons, valued at	2,643,207.16

It is claimed that the above figures are the result of a very careful revision of the ore tonnage and they can be accepted as a conservative estimate of ore known in the mine as of date stated. There is doubt that all of this ore can be extracted profitably, as removal of the portion contained in pillars will be difficult.

The exploration work on the Calvin Horr group, optioned by the company, was continued throughout the year 1924. Some good ore has been exposed but it was not deemed sufficient to warrant equipping the mine for production. On the Antamok property, the shaft has been sunk to "G" level and development work, first at this level and later on "F" level, was done, but

nothing of value has been found on either level. The exploration work is further described in the 1925 Annual Report of the company as follows:

> A raise approximately in a vertical line with the center of the main orebody was driven from "F" level and encountered pay ore within 20 feet [6 meters] and continued in pay ore to the level above. The bottom of the ore at this point has therefore been definitely established as has also the fact that further discoveries of ore in depth are extremely doubtful. Preparation is now under way to drill from "G" level with a diamond drill in an effort to cut the lode at about 1,000 feet [305 meters] below the surface and it is expected that the results of this drilling will indicate the advisability of either sinking the shaft to greater depth or final abandonment of "G" level.

A reduction of capital from 1,400,000 to 200,000 pesos was authorized by the unanimous vote of the shareholders present at the special meeting held January 18, 1926. The number of shares remains at 2,000,000 as before.

The Ukab Mining Company.—This company has been carrying on extensive development work since 1923 on the seven lode claims owned by Mr. P. J. O'Neill. This group is located near the Itogon Road and joins the Bua patented claims on the southwest. The development work done on a large quartz-calcite-manganese vein revealed some valuable ore, assaying high in free gold. During the course of the work in 1925 about 900 pesos worth of gold and silver was recovered.

A small 20-ton Herman ball mill is being installed for treating the ore.

Itogon Mining Company.—This company has recently been granted permission to sell mining securities for the development and exploitation of its eleven full-size mineral claims at Itogon. Each claim is 300 by 300 meters in extent, making a total area of 99 hectares. It lies about 16 kilometers distant in a southeasterly direction from Government Center in the City of Baguio. It is reached via the Bua Road leading out to Baguio, passing the Antamok bodega of the Benguet Consolidated. An easy trail leads from the latter point, passing through the municipal center of Itogon for about 9.6 kilometers to the Sanguilo Camp.

The area covered by the Itogon claims was formerly worked by the Igorrote miners and many of their old workings still exist in a fair state of preservation. Recent development work has exposed a considerable amount of pay ore. The assays made of samples from the lode and from the old dumps showed values of from 16 to 24 pesos per ton. A sample of ore sent to the

Bureau of Science for amalgamation test assayed 39.41 pesos per ton in gold, over 30 per cent of which could be recovered by amalgamation with the ore ground to 40 mesh. It has been estimated that about 500,000 tons of ore, valued at 24 pesos per ton, could easily be developed.

A milling plant is in course of erection. Most of the machinery is already on the ground and the management hopes to start operation soon.

The Balatoc Mining Company.—This company has taken over the interests of the old Acupan Mining Company and has done considerable development work. The property looks very promising and has a large amount of ore already developed. Development work is being pushed vigorously preparatory to erecting a mill. The ore samples submitted to the Bureau of Science for assay carry high values in gold and silver.

The old Acupan group consists of twenty-five full claims and fractions of claims, located about 13 kilometers southeast of the City of Baguio. Twenty-three of the claims cover the mountain side east of Batwaan Creek, and the other two cover the continuation of the main vein on the west.

The gold occurs free and in combination with sulphides in a vein about 20 meters wide containing narrow stringers of hard blue quartz that carry the best values. The vein strikes approximately east and west, has an almost vertical dip, and can be traced easily on its outcrop for about a kilometer. Assays taken at random from the stringers on the footwall of the vein are said to carry average values of from 10 to 100 pesos per metric ton.

According to the latest information furnished by the company, three lodes, Nos. 1, 2, and 4, are now under process of development. Lodes 1 and 4 are each 1.5 meters (5 feet) thick, while lode 2 is 1.35 meters (4.5 feet) only. The approximate quantity of ore already developed, as per data submitted by the company, is as follows:

TABLE 3.—*Ore developed by the Balatok Mining Company.*

Level.	Tons (short).	Value per ton.	Total value.
		Pesos.	*Pesos.*
B—Level No. 1 lode	5,000	30	150,000
Between B and A No. 2 lode	50,884	18	915,912
Between A and A-130′ No. 2 lode	29,491	18	530,838
Between A-130′ and A-265′ No. 2 lode	8,307	18	149,526
Lower and upper levels No. 4 lode	38,461	30	1,153,830
Total	132,143		2,900,106

The Dugong group.—This group consists of five claims located near the Palidan Slide, Suyoc, which Mr. C. F. Starkey has been working since 1921. During 1924 and 1925 he produced 1,316.5 grams of gold and silver valued at approximately 1,730 pesos, in the course of his development work. There are three veins on the property, two of which carry free-milling gold, and the other contains considerable tellurides. The telluride vein varies from 0.7 to 1.25 meters in width; the other two are only 0.7 meter wide. It was found that the values in the telluride vein are very patchy, the assays varying from 5 to as high as 75 pesos per metric ton. The development work is being hampered by the heavy rains.

Placer deposits.—The placer deposits of the Mountain Province district and vicinity have not attracted as much attention as have the lode deposits. It is known, however, that in the past native gold washing had brought a not inconsiderable amount of gold. Numerous pannings made from streams rising from the Benguet mineral region invariably contained gold. The important placer deposits are along Abra River, and the deposit at Comillas Valley was investigated in 1906 by Mr. L. Lehlback, manager of the old Lepanto Mining Company, but nothing has been done up to the present time.

MASBATE DISTRICT

The mineral district of Masbate is located only a few kilometers south of the town of Aroroy, Masbate Province. It is about 400 kilometers south of Manila and is reached within thirty hours by steamer from Manila. The mineralized zone covers an area of about 80 square kilometers. The veins are of the fissure type in andesite, diorite, and pyroclastics. The ore is hard and medium-hard quartz with varying amounts of manganese, iron oxides, pyrites, and calcite. Except for two years, 1909 and 1910, when gold mining all over the Islands was practically at a standstill on account of floods, Masbate has continually produced gold and silver from its mines. It was the leading gold producer from 1912 to 1920, exclusive of the year 1917. From 1921 to 1925 it stood next in production to the Mountain Province district. This was due to the stoppage of operations of the Colorado Mining Company in 1922 and the ever-increasing production of the Benguet Consolidated Mining Company.

Syndicate Mining Company.—Besides its original holdings, this company took over the interests of the defunct Eastern

Mining Company and started milling on February 1, 1914. From that time on it consistently produced gold and silver, and at present it is the leading producer in the district. The character of the ore is quartz-calcite-manganese, with an average value of 13.42 pesos per ton. The ore is treated by the sliming process, grinding to 70 per cent minus 200 mesh in cyanide solution, followed by agitation and filtering. The mill was built in 1913 and is now very old and inefficient. The average operating cost per ton, covering development, mining, milling, and general expenses is 10.10 pesos. The overhead expenses and marketing of bullion are not included.

According to Mr. W. G. Carpenter, superintendent, the company is now considering changes in the treatment process which will lower the milling cost considerably. The method under consideration is the leaching of sands and separate treatment of the slimes.

The production during 1925 was 712,818.3 grams of gold and silver bullion, valued at 639,327.20 pesos; 52,179 metric tons of ore were treated to produce this amount. During 1924, 55,778 metric tons were treated, having a gross value of 718,370 pesos in gold and silver. It was reported that the mill heads are gradually getting lower in value. Present indications are that there is enough ore in sight to run until the end of the year 1926. Experiments in the cheaper treatment of low-grade ore are being undertaken in the United States, but the preliminary reports have not been very encouraging.

Panique mines.—Next to the Syndicate, the Panique is one of the two large producers in Masbate at present. The Panique interest is controlled by Messrs. Schwab and Geringer, two of the veteran American miners in the Philippines. Besides the claims separately held by them they acquired and are now working part of the property of the old Colorado Mining Company. They also control some claims in the Jabuyuan district, south of the town of Aroroy, and now being developed by Mr. J. O. Emberg. The main holdings of the Panique are located south of the Syndicate property on Panique River.

The character of the ore is quartz-calcite carrying a high percentage of free-milling gold that made possible the adoption of combined amalgamation and leaching of the sands with cyanide solution. After passing through the Dorr thickener to recover the water, the slimes go to waste without cyanide treatment. Hence, the total recovery is not more than 70 per cent of the value in the ore. The present capacity of the mill is from 36 to

46 metric tons per day. The average mining and milling cost is 7.70 pesos per metric ton.

In 1924 the quantity of the ore treated was 5,563 metric tons of an average value of 13.20 pesos per metric ton. The bullion produced was valued at 52,748.16 pesos. In 1925, the ore treated was 7,641 metric tons of an average value of 12.67 pesos per metric ton. The bullion produced was valued at 123,248.74 pesos in gold and silver.

Up to the present, the bulk of the ore treated came from the "antigua." This ore is of lower grade than that found in the new underground workings, but the cost of mining is lower and the average returns will compare well with those from the underground ores. The company, however, continues its development work along the veins that carry assay values averaging 35.20 pesos per metric ton. It also proposed some changes in its mill flow sheet, so as to permit of handling the low-grade ores at less cost.

Colorado Mining Company.—This company suspended operations in April, 1922, on account of the depletion of the ore reserves. The mine yielded a fair return upon the original investment and, in general, the enterprise was considered successful. A part of its holdings has been turned over to the Panique Mines, now doing development work, and indications are that the low-grade standing ore and the old fillings carrying values will stand commercial exploitation under the new method of treatment that is being tested.

The Keystone Mining Company.—This company started milling operations in 1914 and stopped during the latter part of 1916, due to the exhaustion of pay ore. Part of its holdings was later acquired by the Colorado Mining Company, which was then at the height of its successful operation, and part was restaked by Mr. Geringer and other local prospectors.

The other properties that have figured more or less in the history of the district are the Mount Cogran and the Gold Bug. The Argus Mining Company, which holds the Balete group, still remains inactive.

Masbate placers.—Attempts were made to dredge the alluvial deposits on the Guinobatan and Lanang Rivers, but they failed. The failure was attributed to lack of thorough testing of the ground before installation of the dredge. Proper examination by experienced engineers of some of the Masbate placers, particularly the one below the first gorge of Guinobatan River, may reveal a new promising field for placer mining.

CAMARINES NORTE DISTRICT

This district is one of the oldest, and is well known in the Philippines. It comprises the area in the neighborhood of Paracale and Mambulao, Camarines Norte Province. The mineralized zone covers, roughly, 400 square kilometers of low-lying land, the highest point having an elevation of not more than 500 meters above sea level. The formations to be found in the area are diorite-schist, granite-gneiss, and sedimentaries. The veins are quartz-calcite, carrying gold, silver, copper, lead, iron, and manganese. These veins were the source of the placer deposits which have made the district famous as a dredging field. From 1907 to the end of 1925 more than 7,200,000 pesos in gold and silver have been cleaned up by the dredges from the alluvial deposits of Paracale and Mambulao.

At the present time only one dredge, belonging to the Philippine Dredges, Limited, is working on Paracale River. Another dredge, belonging to the same company, was closed down permanently at the end of September, 1925. The quantity of material treated in 1924 was 684,776 cubic meters, of an average value of 0.244 peso per cubic meter. The total gold and silver recovered was 151,203 grams, valued at 171,268 pesos. The production in 1925 was higher, amounting to 168,628 grams, valued at 192,607 pesos.

It is predicted that the production from this field will be very much reduced during the ensuing year, unless there is decided improvement in the value of the ground. Several hectares have been dredged a second time, which was made possible by the installation of clay breakers improved by Mr. William Telford, dredge superintendent of the Philippine Dredges, Limited. A large percentage of the values lost in the sticky clay during past operations has recently been recovered.

Lode mining in Camarines Norte has not been very successful. In 1910, the San Mauricio and Tumbaga mines produced 43,395 pesos worth of gold and silver from their development work. In 1911 their operations practically ceased as they were not able to get sufficient ore. Recently the Tumbaga mine was reopened under the direction of Mr. G. H. LeDuc and Mr. E. A. Heise. Some development work has been done, but the work is slow as it is being hampered and made expensive on account of water.

J. R. Reed restaked the old Candelaria claims on the Dinaanan ridge, and the Longos Development Company has taken

up the old Baluarte and adjoining claims at Longos Point, just across the river from the town of Paracale. This group was showing much promise when Mr. Jumper, who had been superintending the work, died in October, 1925, and since then its activity was suspended.

SURIGAO PROVINCE DISTRICT

The present mining activity in Surigao Province is centered on the operation of the Lianga Mines, Limited, an English company, which is dredging along the upper Hinatuan River, near Lianga, on the east coast of Mindanao.

The property of this company consists of twenty placer claims along the upper Hinatuan River. It is 2 kilometers north of Bahi and 9.5 kilometers from the coast. It covers an area of 75 hectares of dredgeable land, 250 meters wide by 3,000 meters long, with an average depth of 6 meters to a false bedrock. The ground was thoroughly tested and reported favorably by Messrs. Kerr and Kane in 1926. In all one hundred five test holes were drilled and three test pits sunk, to determine the value of the property. The average value was estimated to be about 0.50 peso per cubic meter. Most of the gold particles are very fine and flaky, and have been often observed to float on the water. The value is very well distributed up to the surface, but more is found concentrated in pockets, and generally from 6 to 12 meters next to a false bedrock.

The dredging operation is intermittent, due to mechanical trouble in the dredge, which needs repairs from time to time. The dredge was bought at second hand from the Umirey Gold, Limited, of Tayabas. Its actual capacity is 25,500 cubic meters per month, but the recovery is low, amounting to only from 50 to 60 per cent of the value per cubic meter. The recovery is low for several reasons; namely, the very fine and flaky character of the gold, the sticky and clayey nature of the deposit, and the shortage of clean water for gold saving during the dry season.

In 1924 the dredge was in operation only during the last two months of the year, and the bullion produced was valued at 9,894.29 pesos. In 1925 production increased to 46,451 pesos, due to continuous operation throughout the year.

W. S. Burwell has been developing four claims near the coast at Placer, Surigao. This region was previously worked by Filipinos, and the old dumps, estimated to contain from 15,000 to

20,000 metric tons, have been found to carry values of from 10 to 40 pesos per metric ton. Several veins and veinlets have been discovered and one of the outcrops is said to measure 4 meters in width. The ore is free-milling and assays from 7 to 52 pesos per metric ton. One sample of ore tested in the Bureau of Science was found to assay more than 100 pesos in gold. Mr. Burwell recovered from his development work about 344 pesos worth of gold in 1925.

OTHER DISTRICTS

There are other, more or less known areas in the Philippines where alluvial deposits as well as lode mines have been exploited. Among the more important ones may be mentioned Pangasinan, Nueva Ecija, Catanduanes, Mindoro, Cebu, and Misamis.

Pangasinan.—George W. Mentzer has been working on his ten mineral claims at Binalonan, and has operated intermittently a small stamp mill. Examinations of the placer grounds along Agno River were conducted eleven years ago by several engineers, who recommended a more thorough testing of the deposit. However, there is some difference of opinion as to the feasibility of dredging on this field, on account of several adverse conditions noted. Among these conditions are the great depth of the bedrock, the very fine quality of the gold found near the surface which may cause difficulty in saving, the strong stream current and the sudden floods, and the presence of large bowlders.

Nueva Ecija.—Nueva Ecija Province has long been known to contain gold in its stream beds. The gold is alleged to be very pure, brilliant in color, and 958 fine. It is found as rounded particles in alluvium, and sometimes in small grains. One of the interesting features of this region is the presence of platinum in small quantity which was thrown away by the Filipinos, who were ignorant of its value. The area in which paying amounts of gold and silver are found is large. It extends from the Eastern Cordillera to the Rio Grande de Pampanga, between Santor River and a line 8.4 kilometers south of Rio Chico, covering an area of about 1,550 square kilometers.

Catanduanes.—Gold is found along the Pajo, Oco, and other smaller streams of the district. It is claimed that, with proper testing of the ground along the Pajo, an area large enough to float a small dredge may be found there. Very little prospecting has been done in this district.

Mindoro.—But for the disagreeable climate and the prevalence of malaria, northern Mindoro should attract more attention of placer miners. It has been reported that there are large areas which are suitable for sluicing and dredging. During the year 1916, development work on the prospects along Binabay River, preparatory to the sluicing and dragline method of mining, was done, but nothing has materialized.

Cebu.—A new dredging field in the Philippines may be opened up if the final tests, to be undertaken by a group of owners of placer claims in Toledo, Cebu, are satisfactory. The owners have interested the Yukon Gold Company in the possibilities of this district. This group of claims is held by the Toledo Placer Syndicate of Cebu, which has undertaken the preliminary testing of the ground. The property consists of five association claims occupying the lower end of the Toledo River valley on the western coast of Cebu. It is approximately 42 kilometers by highway from the town of Cebu and 1.5 kilometers north of the town of Toledo. It covers an area of about 300 hectares and a length of approximately 10 kilometers. The whole area is practically a level plain. The lower end of the Toledo claim is right on the tide flat.

Pannings made of the river sand sometimes reveal some coarse bright colors. The value is irregularly distributed up to the surface, but a greater number of colors is to be found next to a false bedrock of blue clay at a depth of 20 meters. The preliminary testing showed values ranging from 0.10 to 5.33 pesos per cubic meter.

Misamis, Mindanao.—Misamis is one of the well-known gold districts in Mindanao. This district has been idle for a long time. The principal native workings were located along Iponan and Cagayan Rivers. The placer deposits in the district are of two general types. They are bench placers and recent river deposits. It is believed that, in spite of the great amount of gold produced by the Filipinos from these deposits, modern dredging or large-scale sluicing would hardly pay. Over the divide, on the headwaters of Pulangui River to the southeast, there are gravels which, under systematic testing, may prove valuable.

COPPER, LEAD, AND ZINC

By ANTONIO D. ALVIR

Copper.—At present, no development is in progress on any of the copper-ore deposits of the Philippine Islands. This inactivity in copper mining is due to lack of capital and to the inaccessibility of the valuable deposits. To these may probably be added the fact that the nearest concentrating mills, leaching plants, or copper smelters are located in Japan, and freight rates are prohibitive.

The best-known copper deposit and the one which has been worked since Spanish days is the Mankayan copper deposit in Mountain Province.

Since the cessation, about three years ago, of development work in these deposits, financed by Phil. C. Whitaker, only the assessment work has been kept up. The development has shown that the ore persists to a depth of at least 78 meters below the old Spanish workings. Not enough work has been done to warrant a reliable estimate of the amount of available copper ore, although the deposit has always been considered the most valuable in the Philippines. It is reported that there are three parallel ore bodies, 100 to 300 meters wide and several kilometers long. They are large, irregular, breccia veins in altered quartz porphyry. In general, the copper values in the ore run from 1 to 3 per cent, but locally there are rich pockets running between 10 and 20 per cent, and sometimes as high as 40 per cent. The ore minerals are enargite, chalcocite, luzonite, covellite, chalcopyrite, and pyrite in a quartz gangue with kaolinite.

The Oriental Mining Company, composed entirely of Filipinos, has for some time been doing a little desultory exploitation in the copper-ore deposits situated in Barrio Aglao, San Marcelino, Zambales. The ore occurs in many small, narrow fissure veins which are too widely separated for economical mining. The deposit is small, and the ore is of poor quality. The ore minerals are chalcopyrite and pyrite in a quartz gangue. Our knowledge of this copper deposit is limited.

In Marinduque, between Santa Cruz and Torrijos, about 2 kilometers uphill from the lead and zinc deposits and not over

5 kilometers from a good harbor, is a deposit of copper ore which, according to E. E. Calvin, secretary-treasurer of the Marinduque Mining Company, has an average copper content of about 14 per cent, with some rich pockets running as high as 29 per cent. The deposits are probably the oxidized portion of the dike deposit of primary and secondary sulphide minerals. The ore minerals are chalcocite, malachite, azurite, and probably also oxides of copper. The ore carries a little gold and silver. No development has been done on these deposits, and the quantity of the available ore is unknown. Other known but undeveloped copper deposits of more or less importance are in Benguet and Pangasinan, where the ore is an oxide of copper (tenorite), and in Batangas, Mindoro, Masbate, Panay, and Mindanao.

Lead and zinc.—There has never been any commercial production of lead and zinc in the Philippine Islands, although lead and zinc deposits have been known for a long time. The best-known deposits are those of Marinduque.

The Marinduque deposits are situated between Santa Cruz and Torrijos, about 3 kilometers from a good harbor. They are owned by the Marinduque Mining Company, which has carried on development work on fifteen claims, from 1916 to 1920, when work was suspended on account of the crisis of 1920. A little development work is going on at present. The deposits are in the form of dikes in andesite, varying from 4 to 10 feet wide. The ore minerals are galena and sphalerite in a quartz gangue. Some rich pockets run as high as 60 per cent lead, others carry as much as 45 per cent zinc, and some portions carry 2 to 3 per cent copper. The average run of the ore is about 6 per cent lead and 5 per cent zinc. In addition, it carries between 2 and 3 pesos worth of gold per ton. For the purpose of experimenting on the concentration of the ores a small hand jig has been installed on the premises.

An American mining expert, Bell of the American Smelter and Refining Company, recently visited these deposits.

Other known lead deposits are in Milagros, Masbate, where Mr. Schwab has done a little development work, and on Mount Acsubing, Cebu, where the Spaniards made several attempts to mine galena without much success. In Paracale there are gold veins which carry much galena and sphalerite, but these have not become sufficiently important for the gold companies to attempt to save.

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OTHER METALLIC MINERALS

By VICTORIANO ELICAÑO

Antimony.—The world's most important source of antimony, stibnite, is known in the Philippine Islands. The Bureau of Science has a small specimen, a fibrous mass, from Batangas Province, Luzon. It is claimed that small specimens have been received also from Surigao, in Mindanao. The principal world producer of this metal is a next-door neighbor, China.

Arsenic.—Orange red sulphides of arsenic, orpiment and realgar, are reported from two places in the Philippines. Red crystals of realgar are found on a yellow coating of orpiment in pieces of slag (?) from the old Santa Barbara furnace at Mankayan, Mountain Province. A fine specimen of orpiment with realgar is in the Bureau of Science collection. The locality is given as barrio Malaga, Tinambakan, Samar. The Ateneo de Manila museum has specimens of realgar, but without any locality label. Orpiment and realgar are mined on a large scale in China.

Mercury.—The chief mineral of mercury, cinnabar, is reported to occur in the Philippine Islands. Minute red crystals of cinnabar were found in some of the samples from Batwaan Creek, Benguet Subprovince, Luzon, the cinnabar remaining in the pan with the gold. A sample of cinnabar in massive form has been brought to the Bureau of Science from Coron, Busuanga Island, but its occurrence in that locality is considered doubtful. The native metal is reported to occur in small crevices and pockets in the vicinity of Mount Isarog in Camarines Sur, and also in Panay. It is claimed that the locality on Mount Isarog is known only to Negritos.

Tin.—The principal mineral of tin, cassiterite (tin oxide), is reported from some of the southern islands. Stream beds in the interior of Palawan, about 75 kilometers south of Puerto Princesa, are said to contain placer tin. Considerable stir was caused some twenty years ago by the reported discovery of tin in Mindanao, but it seems that the reports were mostly based on hearsay. The Malay States lead in the world's production of tin, and over 90 per cent of the tin of southeastern Asia and Oceania is obtained from placers.


RE-UNION

3/19/46

Dear Paquito,
I still remember your phrase - "look south, look north, look east & west - she's ---- so I guess you remember too... Sincerely yours, shall not continue!
Paz

Paquito! We're missing you a lot. Augusto

To dear Engineer Castro

Hello Francis:
Here's wishing you good luck in all your undertakings.
R. B. Panogio

To Francisco,
We'll be waiting for you to come back... and maybe another
B.P. Ibig.

Hello Kiko,
Here's hoping you luck and success
Carso.

To Kiko Castro,
loads of [illegible] luck

Dear Mong Kiko,
Kumusta ka. Mayroon naba?
Pepito T.

Hi Paquito!
Here's us!
How's you!
Wish you the best of luck in your studies. Salinda

Castro,
We missed you here
F. Yanga

TO PLANGKY! —
WHO, BUT FOR THE WHIMS OF DAME FATE, WOULD HAVE BEEN WITH US IN THIS PICTURE.
Aq.

Hello Pareng -
Hows in your americano made - Happy sailing - Josie.

(EDITOR'S NOTE: YOLANDA IS REFERRING TO JOSIE'S COMMENTS.)

Hoy Kiko - Take! take! nasama you!
- Yolanda

ASBESTOS

By LEOPOLDO A. FAUSTINO

There is little production of asbestos at the present time. The best-known deposit and which was worked in 1918 and 1919 is near Bangui, Ilocos Norte Province. The asbestos in this deposit is classed as amphibole, containing the minerals tremolite and actinolite, and chrysotile commonly associated with serpentines. It occurs as cross fiber, usually veined; as parallel fiber, also veined and with the fiber parallel to the vein; and as massive fiber, in pockets. The bulk of the deposit occurs as parallel fiber, while the cross fiber and the massive fiber have hardly made their appearance up to the present time.

The Ilocos Norte asbestos deposit was worked in 1918 and 1919 by the Ilocos Asbestos Products Company to supply raw materials for the manufacture of asbestos articles in a small plant at Santa Ana, Manila. In 1918 they produced 70 metric tons of crude asbestos, valued at 5,250 pesos, and in 1919, 375 metric tons, valued at 37,500 pesos. The articles manufactured were asbestos roofing, asbestos siding, asbestos shingles, asbestos steampipe coverings, high-grade asbestos cement, asbestos stucco, asbestos ceiling boards, asbestos mastic, and asbestos paints. In 1920 the company suspended operations, the reason assigned being limited funds.

The asbestos deposit of Ilocos Norte is located in a region of metamorphism. The asbestos is believed to have been derived from pyroxenites, through processes of serpentinization and amphibolization. Asbestos is also reported to occur near Salasa in Pangasinan, in Antique, and near Subic, Zambales, within the army and navy reservation. The latest asbestos locality to come to the attention of the Bureau of Science is near Abra de Ilog, in Mindoro. The sample appears to be a combination of parallel fiber and massive fiber, and is of a poor grade. The interesting feature of this deposit is the fact that some of the samples appear to occur in limestones which have been partly metamorphosed to amphibolitic rocks. This deposit is the source of a small production, which is shipped to Manila and sold at about 40 pesos per metric ton.

ASPHALT AND RELATED BITUMENS

By LEOPOLDO A. FAUSTINO

Natural asphalt and similar products are found in the extreme northwestern peninsular portion of Leyte, in the vicinity of the town of Villaba. The asphaltic material occurs as impregnations of sandstones, limestones, and clay tuffs, which appear to have remained behind after the lighter organic constituents volatilized and migrated upward. It also occurs in distinct fissure veins in clay tuff; the fissures and cavities apparently were once filled with liquid petroleum, which has subsequently undergone further distillation. The deposit has been variously estimated to contain between 2,000,000 and 10,000,000 metric tons.

Asphalts and bitumens include a wide variety of hydrocarbon materials. These varieties have been given special mineral names, such as gilsonite, grahamite, elaterite, ozokerite, etc. It appears that none of the descriptions of those recognized bitumen minerals can be applied exactly to the various asphalts and bitumens of Leyte. As a matter of fact, the Leyte bitumens are not true asphalts, as all of them are paraffine bearing, and asphalt as commonly defined is derived naturally or artificially from petroleum with an asphaltic base. Table 1 [1] contains data of the physical properties of the three principal varieties of natural bitumens found in Leyte.

TABLE 1.—*Physical properties of natural bitumens from Villaba, Leyte.*

Property.	Outcrop.		
	A and B.	D.	E, F, and G.
Specific gravity	1.05	1.016	0.98–1.02.
Hardness	2.00		1.5.
Color	Jet black	Black	Brownish black.
Streak	Black		Light brown.
Luster	Brilliant		Dull.
Structure	Columnar	Viscous	Schistose.
Fracture	Conchoidal		Irregular schistose.
Flow	Intumesces, softens, and flows imperfectly at 150°C.	At 35°C	At 75°C.

[1] Pratt, W. E., Petroleum and residual bitumens in Leyte, Philip. Journ. Sci. § A 10 (1915) 262 and 264.

TABLE 2.—*Analyses of bitumens from outcrops E, F, and G, Villaba, Leyte.* [a]

Constituent.	Sample 1.	Sample 2.
	Per cent.	*Per cent.*
Moisture and loss at 100°C	0.56	2.80
Petrolene	63.45	26.26
Asphaltene	28.59	22.53
Organic nonbitumen	4.68	11.64
Mineral matter	2.88	36.78
Total	100.16	100.01

[a] Analyses by A. H. Wells, chemist, Bureau of Science.

The Leyte deposit was first worked during the latter part of 1918, by the Leyte Asphalt and Mineral Oil Company. During the three years following, 1919 to 1921, they produced a grade of rock asphalt which was successfully used as road-paving material in Cebu and in other parts of the Philippines. The production was as shown in Table 3.

TABLE 3.—*Production of Leyte asphalt, 1919, 1920, and 1921.*

Year.	Production.	Value.
	Metric tons.	*Pesos.*
1919	1,400	21,000
1920	2,000	30,005
1921	766	11,290

In 1920 about 20 tons of the Leyte asphalt were sent as samples to Australia and Japan. It has been reported that the material sent to Japan was used with success on the streets of Tokyo. In 1922 all operations ceased, and soon afterward the controlling interest in the company was purchased by Japanese interests, who had planned to undertake extensive development of the property. The deposit, however, has not been worked since 1921.

According to the Bureau of Customs, the importation of asphaltum into the Philippine Islands in 1924 was 2,421 metric tons valued at 128,691 pesos, while in 1925 it amounted to 1,770 metric tons valued at 97,863 pesos. Table 4 gives the countries of origin of asphaltum imported into the Philippine Islands.

TABLE 4.—*Asphaltum imported into the Philippine Islands in 1924 and 1925, by countries of origin.*

Country.	1924		1925	
	Metric tons.	Pesos.	Metric tons.	Pesos.
United States	2,418	128,462	1,749	96,556
United Kingdom	1	62		
Great Britain			1	100
Czechoslovakia	2	150	2	163
Germany		17	4	382
Netherlands		3	3	156
Mexico			11	506
Total	2,421	128,691	1,770	97,863

CEMENT

By FRANCISCO D. REYES[1]

The Bureau of Science has from time to time made surveys of cement raw materials, and numerous chemical analyses have been made to determine the most promising deposits. In 1910 and 1911, requests for reliable information on the possibilities of manufacturing cement locally were sent to the Bureau of Science, and the division of geology and mines undertook a more thorough examination of the most promising manufacturing sites. In September, 1911, W. E. Pratt of the division of mines, in a private report on Portland cement raw materials available for local cement manufacture, named the following localities, any one of which would be suitable as the site for a manufacturing plant:

1. Vicinity of Manila, Rizal Province.
2. Batan Island, Albay Province.
3. Romblon Island, Romblon.
4. Masbate, Iloilo, and Bohol.
5. Vicinity of Danao, Cebu.
6. Vicinity of Naga, Cebu.

While with the raw materials from the above localities Portland cement of indifferent character could be made, it is absolutely essential that the operation be commercially profitable as far as can be determined by investigation and proper tests. Pratt recommended the vicinity of Naga (the present site of the Cebu Portland Cement Company) because of the excellence of the raw materials and the low cost of obtaining them, and because of its central location, making distribution of the finished cement a simple matter, due to availability of railroad connection with the port of Cebu and sea-water transportation from the port.

Portland cement is such a bulky material, compared with its price, that a factory in the Philippines should be ideally located with respect to markets to be served and should enjoy the best transportation facilities for its product and for needed supplies. Coal, one of the largest items of cost, and gypsum, the most expensive raw material, will have to be imported generally, as experience has shown that the local production cannot be depended upon.

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[1] Chief, division of general, inorganic, and physical chemistry, Bureau of Science.

In 1914, the Rizal Cement Company, Limited, established the first cement factory in Binangonan, Rizal Province, near the shore of Laguna Lake. The plant was erected and furnished under the supervision of Krupp, of Germany, with a guaranteed capacity of 500 barrels of cement per day. The raw materials used were a pure, hard limestone, located about 6 kilometers from the plant site, and volcanic tuff (adobe stone) and clay found near the factory. Coal and other supplies were sent by water from Manila up Pasig River to the lake shore at Binangonan, a distance of about 18 kilometers. The finished cement was sent to Manila over the same route. In July, 1915, the cement manufactured by the new factory first appeared in the local market, under the trade name of "Rizal Cement."

The factory was never able to work to its full capacity, due partly to the inability of the company to secure needed spare parts and other supplies from Germany on account of the World War and, to some extent, to the difficulties encountered with the clay material. The frequent formation of the so-called "ring" in the rotary kiln (about once in twelve hours), which might have been caused by an excess of fluxing materials in the clay, decreased the output of the rotary kiln because of the time lost in burning off the ring. The fact was that from July, 1915, to June, 1916, 69,100 barrels of cement were manufactured, or about 46 per cent of the rated capacity of the factory.

The records of cement tests of the Bureau of Science show that the Rizal cement factory could not be depended upon to produce a uniform quality of Portland cement. It often failed to comply with the chemical limits or the physical requirements of the Government specifications for Portland cement then in force. In this connection, it might be of interest to quote a paragraph in W. E. Pratt's report in 1911:

> The only source of calcareous materials in the vicinity of Manila is the pure limestone occurring at Binangonan and Montalban. This limestone is thoroughly crystalline and very hard. Consequently both quarrying and crushing cost would be high. The common clay of Binangonan has been analysed by Dr. A. J. Cox and found undesirable for a cement clay because of the very low silica-alumina ratio. The only clay in the vicinity of Manila which is known to be chemically suitable for use with a pure limestone is the volcanic tuff or "adobe" stone so widely used in construction. This is a fragmental material containing pieces of scoria, basaltic pebbles, and volcanic ash in varying and non-uniform proportions. For this reason, the tuff is not desirable and it is a question if it could be used at all in actual practice.

The Rizal Cement Company, Limited, operated at a loss and its inability to manufacture cement of uniformly good quality forced the company to close the plant in March, 1919.

As stated above, W. E. Pratt, in the interest of a local American firm, made in 1911 a detailed examination of possible sites for a cement plant and recommended the vicinity of Naga as the most promising site. The burning tests conducted by the Bureau of Science proved beyond doubt that Portland cement of excellent quality could be manufactured from the representative samples obtained from Naga. In spite of these favorable reports, private capital was apparently not convinced of the commercial possibilities of a cement plant at Naga and the project was abandoned.

The obvious advantages of concrete structures in a tropical climate led to a rapidly increasing use of cement. The Philippine Government was and is at present the largest consumer of cement for the construction of permanent public improvements and large irrigation systems. So, when private capital was afraid to invest in this new Philippine industry, the Government decided in 1922 to establish a cement factory at Tinaan, Naga, Cebu. Accordingly, the Cebu Portland Cement Company was organized, with an authorized capital of 5,000,000 pesos, of which 2,750,200 pesos was paid in. A modern cement plant, with a daily capacity of 1,000 barrels, was duly erected and in September, 1923, the first cement manufactured by the company was placed in the market under the trade name of "Apo Cement." The quality of the cement manufactured from the beginning was very satisfactory and complied in every respect with the Philippine Government specifications for Portland cement. However, due to the keen competition of imported cements, with the consequent drop in price, Apo cement was sold at a loss during the first two years of operation.

In 1922, the declared value per barrel of imported cement as given in the annual report of the Bureau of Customs was 5.12 pesos; in 1923, 4.53; in 1924, 3.82; and in 1925, 3.22. In January, 1924, the wholesale price of cement in the local market was 6.02 pesos per barrel, and in December of the same year it dropped to 4.80 pesos per barrel. The effect of the Government cement factory on the market price of cement was, indeed, very marked. The substantial reduction in the cost of cement was undoubtedly a great benefit to the consumers who paid from 1.50 to 2 pesos less per barrel. The loss sustained by the Government

cement factory was more than compensated by the savings made in the cost of cement purchased by the Government.

To enable the Cebu Portland Cement Company to meet the competition of foreign cements, the legislature increased the import duty in November, 1924. At the same time, substantial economies were made in the operation and administration of the cement plant, which placed the company on a sound paying basis.

Table 1 gives the yearly production of the Cebu Portland Cement Company, and the cost of manufacturing the cement in bulk (bin cost).

TABLE 1.—*Production of Cebu Portland Cement Company in 1923, 1924, and 1925.*

Year.	Bin cost.	Production.
	Pesos.	*bbls.*
1923 [a]	6.18	37,557
1924	3.24	264,981
1925	2.63	283,167

[a] Four months.

At present the entire production of the factory is shipped to Cebu by rail at heavy expense. Further economies could undoubtedly be made, particularly in transportation expenses, if an adequate pier were constructed near the cement plant, from which the finished cement could be shipped direct to points of consumption. Similarly, factory supplies, such as coal, gypsum, etc., could be obtained at a minimum cost.

Table 2, computed from the report of the Insular Collector of Customs, shows the consumption of cement in the Philippine Islands for 1922, 1923, 1924, and 1925.

TABLE 2.—*Cement consumption in the Philippine Islands in 1922, 1923, 1924, and 1925.*

[Quantities are given in barrels.]

	1922	1923	1924	1925
Cement imports	305,990	312,648	192,448	214,463
Local production	----------	37,557	264,981	283,167
Total cement	305,990	350,205	457,429	497,630
Export of local cement	----------	----------	20,370	6,010
Total consumption	305,990	350,205	437,059	491,620

CLAY PRODUCTS

By TIMOTEO DAR JUAN [1] and FRANCISCO D. REYES [2]

Clays suitable for use in the manufacture of pottery, earthen jars, common bricks, etc., are found in practically every part of the Philippines.

Pottery making and the manufacture of clay products are carried on in thirty-six of the forty-eight provinces of the Islands. The extent of the industry as reported by the provincial treasurers to the Bureau of Science is shown in Table 1.

TABLE 1.—*Value of clay products manufactured in 1925, by provinces.*

Province.	Pesos.	Province.	Pesos.
Abra	2,150	Marinduque	600
Albay	8,025	Masbate	(a)
Antique	1,869	Misamis	340
Batanes	522	Mountain	(a)
Batangas	20,570	Nueva Ecija	2,094
Bulacan	2,354	Occidental Negros	11,688
Cagayan	1,933	Oriental Negros	1,948
Camarines Norte	(a)	Palawan	18
Camarines Sur	2,700	Pampanga	67,686
Capiz	2,700	Pangasinan	4,618
Cebu	18,070	Rizal	5,250
Davao	(a)	Romblon	494
Ilocos Norte	10,227	Samar	134
Ilocos Sur	5,376	Sorsogon	1,180
Iloilo	7,033	Sulu	(a)
Laguna	1,878	Tarlac	4,760
La Union	10,069	Zambales	5,778
Leyte	720	Zamboanga	(a)

[a] No report for 1925.

The returns from several provinces appear to be abnormally low, particularly from Rizal Province, which supplies the bulk of the clay products sold in the City of Manila.

In the vicinity of large cities, the clay deposits are extensively worked, because the manufactured products are easily sold. The

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bulk of the clay products sold in Manila comes from the potteries located along the banks of Pasig River, at Santa Ana in Manila, at San Pedro Macati and Pasig in Rizal Province, and at San Pedro Tunasan in Laguna Province. Ordinary water containers come mostly from Caloocan in Rizal Province, and from Baliuag and San Rafael in Bulacan Province.

Pottery.—The unglazed red pottery used in making cooking utensils and water containers is made from a mixture of alluvial clay and varying quantities of river sand to counteract the shrinkage. The clay mixture is shaped by hand on a small wooden wheel, air-dried until it becomes leathery, and then burned into biscuits. Frequently the clay mixture has a tendency to crack on air-drying. It is a common practice to beat the shaped articles with wooden paddles. This operation renders the clay denser and overcomes the cracking to a great extent, and the thickness, which varies from 4 to 6 millimeters, becomes more nearly uniform. To fire the air-dried pottery, a shallow hole is generally dug in the ground, the pots are laid in the hole, covered with straw or rice husks and bamboo sticks, and then fired until the articles acquire a characteristic red color. The whole firing operation lasts only about one hour. The temperature attained by this primitive method of burning ordinary pottery as determined by means of a thermocouple inserted in the center of the pile is about 700° C.

Larger, barrel-shaped containers for drinking water are usually burned in long kilns of semicylindrical shape for about two days. To burn one hundred sixty water containers, about 55 centimeters high by 35 centimeters maximum diameter and 1 centimeter thick, requires 1.17 cords of wood (4.24 cubic meters). The highest temperature is 800° C.

Large earthenware jars called *tapayan,* or *tinajas,* are semivitrified liquid containers and are made in practically the same way as are cooking pots, except that the air-dried ware is given a coat of lye prepared from bamboo or wood ashes and the burning is carried on at a higher temperature, to incipient vitrification, in a long kiln of semicylindrical shape. The finished product has a dark brown color and is more impervious to water than are the ordinary red pots. The burning process for the tapayan takes about one week and consumes from three to four times as much fuel as is required in burning containers for drinking water. The highest temperature reached is about 1,200° C. Any malformed or damaged tapayan is broken

into pieces which are used in the preparation of the crystallizing surface in the manufacture of salt by solar evaporation of sea water.

Flower pots, bowls, and fancy articles are made from a better grade of material, which is found at Los Baños and San Pedro Tunasan in Laguna Province. Unglazed pottery made with clay from these places is usually coated with a white or red clay and polished by means of a smooth piece of hard wood or carabao horn. The biscuits used for the glazed pottery are made of the same clays, mixed with varying quantities of Ilocos silica, to give the requisite strength for stoneware.

Several attempts have been made to produce porcelainware from Philippine materials but they have met with little success owing to inability to find raw materials in quantity and sufficiently cheap for the local product to compete with the imported product. For those who are interested and who desire to acquaint themselves with the different clays analyzed by the Bureau of Science, Table 2 may prove of interest.

From these analyses it will be seen that Los Baños and Calamba clays approximate kaolinite in composition. The clays from the Nasugbu region in Batangas Province are usually low in alumina and relatively high in silica. Trials made by mixing proportionate amounts of Los Baños and Nasugbu clay gave fairly good results in pottery making. The present practice, however, is to mix Los Baños clay with a sufficient quantity of Ilocos siliceous material to increase the silica content of the mixture. Practical tests conducted with Matiquio's clay prove this clay to be suitable for making hard earthenware, in which the original color of the biscuit is to be covered by a glaze. Clays from Malinta, Bulacan, San Pedro Macati, Pasig, and Mandaloyon are alluvial clays containing a high percentage of iron oxide, and they are used mostly for making cooking pots and water containers.

Common bricks.—The common red brick of local manufacture is made by the "soft-mud process," has a relatively low compressive strength, and is rather porous and soft. Bricks have been made by the Bureau of Science with clay mixtures from Santa Ana, San Pedro Macati, and Pasig, and it has been demonstrated that good building bricks of good crushing strength can be produced from materials obtained from those places, by proper burning alone. In order to determine the influence of proper burning upon bricks, a sample of the clay mixture in

TABLE 2.—*Analyses of Philippine clays.*

Region, province, locality, sample No.	Silica (SiO_2).	Alumina (Al_2O_3).	Fluxes.				Total fluxes.	Titanium (TiO_2).	Loss on ignition.	Water (H_2O) below 110°C.
			Iron (Fe_2O_3), (FeO).	Lime (CaO).	Magnesia (MgO).	Alkalies (Na_2O), (K_2O).				
Mount Maquiling, Laguna Province:										
No. 2 Los Baños	44.15	36.54	1.04	0.15	0.00	0.98	2.17	1.14	13.50	2.64
No. 3 Vicente Jesus mine	43.32	41.48	0.32	0.04	0.59	0.38	1.69	0.00	14.12	0.00
No. 5 Laguna Province	42.06	32.04	0.33	0.48	0.32	1.17	2.90	1.10	20.42	2.08
No. 6 Los Baños	45.24	37.31	1.00	0.66	0.00	1.69	3.35	0.98	12.67	1.24
No. 7 Pajo Arroyo	44.30	37.28	1.47	0.39	0.42	1.00	3.28	1.36	12.56	1.60
No. 12 Calamba	61.98	26.22	0.12	0.60	0.72	0.34	1.78	0.00	10.55	0.00
No. 19 Wolfson mine	49.95	31.84	3.96	0.36	0.70	0.64	5.66	0.00	11.90	0.00
Bagong Bola Creek	49.42	30.45	1.61	0.00	0.21	0.16	1.98	1.11	11.72	5.86
Bagong Bola Creek	43.83	31.86	5.86	0.14	0.11	(a)	6.11	0.80	15.04	2.71
Pajo Cañon	55.99	28.77	0.89	0.18	0.03	0.17	1.27	0.91	11.59	2.42
Pajo Cañon	42.23	37.32	1.41	0.23	0.07	0.46	2.17	1.00	15.84	1.92
Pajo Cañon	43.28	37.85	3.39	0.08	0.04	(a)	3.51	1.25	14.20	0.89
Point Alipasio	43.16	38.64	1.19	0.09	0.14	0.10	1.52	1.54	14.55	1.42
Nasugbu, Batangas Province:										
No. 13 Nasugbu	62.78	23.85	1.60	0.15	0.00	2.61	4.36	0.78	8.84	0.00
No. 20 East of Nasugbu	65.18	19.07	3.93	0.00	0.28	1.16	5.27	0.70	9.04	0.00
No. 35 Near Nasugbu	57.45	18.08	8.40	1.41	0.00	1.42	11.26	0.58	8.56	6.08
Albay Province: Locality not known	71.16	16.94	0.48	0.57	0.23	6.10	7.38	0.58	3.22	1.56
Matiquio, Jala Jala Peninsula, Laguna Province	61.00	19.71	3.49	0.34	0.07	0.84	4.73	0.95	8.18	5.97
Malinta, Bulacan Province:										
No. 30 Tinajeros River, alluvial clay	60.24	18.73	7.19	1.78	2.06	1.86	13.04	0.00	13.84	0.00
San Pedro Macati, Rizal Province:										
No. 33 Pasig River, Mandaloyon, alluvial clay	52.53	21.01	8.40	4.04	2.58	2.68	17.70	0.00	9.08	0.00
Laoag, Ilocos Norte Province:										
Granulite dike, source of "silica"	72.56	15.13	2.54	2.01	0.95	5.62	0.00	(b)	----	0.03

[a] Small.

[b] TiO, trace; MnO, 0.46.

daily use at a pottery works in San Pedro Macati was taken to the Bureau of Science and molded into bricks of $2\frac{3}{8}$ by 2 by $4\frac{3}{4}$ inches. Half of the number of bricks made was taken back to the pottery and burned with other wares in the open air, as usual. The other bricks were burned in the experimental kiln of the Bureau of Science. Temperatures were determined at the pottery with a thermocouple and with Seger cones in the experimental kiln. The results, as well as the crushing strength of the test bricks, are given in Tables 3 and 4.

TABLE 3.—*Temperature record of burning in an experimental kiln and in a pile of straw at pottery.*

At pottery.		In experimental kilns.		At pottery.		In experimental kilns.	
Time.	Temperature.	Time.	Approximate temperature indicated by Seger cones.	Time.	Temperature.	Time.	Approximate temperature indicated by Seger cones.
a. m.	°C.	*a. m.*	°C.	*a. m.*	°C.	*a. m.*	°C.
1.45	30	4.00	30	2.35	450		
		p. m.				*p. m.*	
1.50	90	1.00	970	2.40	355		
1.55	250	1.20	1,010	2.45	290		
2.00	515	1.45	1,050	2.50	240		
2.05	675	2.05	1,090	3.00	200		
2.10	745	2.25	1,150	3.05	160		
2.15	755	3.25	1,190	3.10	130		
2.20	725			3.15	110		
2.25	665			3.20	70		
2.30	555			3.25	60		
				3.30	50		

TABLE 4.—*Compressive strength of test bricks.*

Burned at pottery.[a]		Burned in experimental kiln.[b]		
Kilograms per square centimeter.	Pounds per square inch.	Approximate burning temperature.[c]	Kilograms per square centimeter.	Pounds per square inch.
		°C.		
252	3,596	1,010	262	3,885
207	2,959	1,050	260	3,709
203	2,896	1,090	261	3,733
223	3,192	1,150	420	5,993
193	2,754	1,190	428	6,118

[a] All bricks removed at end of operation.
[b] One brick was removed when each cone fused.
[c] Temperatures determined by Seger cones.

There is a great demand for common bricks of good quality. In 1925 the Philippine imports of common bricks amounted to

954,437,000 valued at 44,652 pesos. Common brick is a popular building material for certain kinds of construction, such as apartment houses, walls, etc.

Silica bricks.—Silica brick is made from a highly siliceous material with a small amount of lime to serve as binder. It has good refractory properties and could be used as fire brick. Siliceous materials are found in various places, but the deposits of some commercial importance are those of Lubang Islands north of Mindoro, Laoag of Ilocos Norte Province, Baguio of Mountain Province, and Paracale of Camarines Norte Province.

The sand deposits of Lubang Islands are found along the southern shore of Looc Bay, from the barrio of the same name to Balacbalac Point, and along the shores of Tabahin Bay, which lies between Caybanac and Natulo Points. The deposits are found both above and below the present shore lines and, together, cover an area of about 2.5 square kilometers. Between the high-water and the low-water marks the sand is subjected to constant agitation by the waves, currents, and tides, with the result that concentration is taking place and the remaining product is almost pure quartz. The width of the area containing the clean quartz sand averages 2.5 meters extending throughout the length of both the Looc and the Tabahin shores. From the high-water mark to the foot of the hills, the sand is mixed with greater or less quantities of clay. Below the low-water mark the sand extends into the sea about 200 meters. The probable thickness and average width of the deposit under the sea is not known, as no soundings have been taken. The depth of the concentrated sand between the high-water and the low-water marks is over a meter, and there are wells above shore line in the vicinity of Looc that have clean sand bottom at a depth of from 2 to 3 meters. Data on hand are not sufficient to make even an approximate estimate of the total amount of sand available.

Deposits of vein-quartz gravel and bowlders are also found along the coast. The gravel has accumulated in great quantities in all the inlets, and the supply is fairly large. The principal areas of accumulation are the northern shore of Looc Bay toward Tumbaga Point, and from Antipolo Point to Pula Point near the town of Agcauayan. The gravel is also found on the east shore of Lubang Island from Caybanac Point to Quebrada Point, and around the southern shore from Natulo Point to Balacbalac Point. Patches of concentrated quartz gravel are also to be found on the northern shores of Golo Island from

Bulacan toward Caypandan Bay. The gravel ranges in size from that of a pea to more than 75 millimeters in diameter and is mixed with quartz bowlders weighing from a few kilograms to a ton or more.

Table 5 gives the analyses of raw materials that can be utilized for fire-brick manufacture.

TABLE 5.—*Analyses of siliceous materials.*

[Numbers give percentages.]

Constituent.	Lubang quartz.	Lubang sand.	Baguio siliceous sinter.
Loss on ignition	0.34	0.80	1.04
Silica (SiO_2)	97.49	86.60	92.28
Ferric oxide (Fe_2O_3)	Trace.	0.48	
Aluminium oxide (Al_2O_3)	1.58	8.12	6.06
Lime (CaO)	Trace.	1.20	0.42
Magnesia (MgO)	Trace.	0.22	0.11
Manganese oxide (MnO_2)	Trace.	Trace.	
Alkalies (K_2O+Na_2O)	0.50	2.58	

Experiments conducted by the Bureau of Science proved that Lubang quartz and sand mixed with Los Baños clay are suitable for fire-brick making. The bricks made by the Bureau of Science have been used to line the boiler furnace of the institution and have stood the test of over two years of service. The siliceous sinter of Baguio or the silica deposit of Laoag mixed with the proper quantity of a binder, such as lime, may prove to be excellent material for refractory brick making. Table 6 shows the analyses of some Philippine limestones, from which lime may be prepared.

TABLE 6.—*Analyses of some Philippine limestones.*

[Numbers give percentages.]

Constituent.	Cebu.	Binangonan, Rizal, 1912.[a]	Binangonan, Rizal, 1918.	Montalban, Rizal, 1912.[a]	Montalban, Rizal, 1918.	Palsabañgan, Tayabas.[b]
Loss on ignition	43.45	43.31	43.39	43.04	43.98	43.48
Silica (SiO_2)	0.86	1.12	0.88	0.94	0.26	0.69
Iron and aluminium oxides (R_2O_3)	0.23	0.15	0.48	1.14	0.09	0.35
Lime (CaO)	54.67	53.78	54.39	54.61	54.97	54.68
Magnesia (MgO)	0.46	1.19	0.68	0.22	0.72	0.48
Alkalies (K_2O+Na_2O)		0.77		0.56		

[a] Analyzed by Forest B. Beyer.

[b] Analyzed by F. D. Reyes, chemist, Bureau of Science.

Sand-lime bricks.—Considering the great popularity in the Philippines, and especially in Manila, of low buildings for residential purposes, conditions are very favorable for the commercial manufacture of bricks, building blocks, tiles, and ornamental stones from sand and lime. The experiments of Reibling and Reyes in making sand-lime brick and artificial sandstones have proven that Philippine materials are suitable for the manufacture of these articles. Recent experiments with Baguio siliceous sinter have proven that this material may be added to those already described by Reibling and Reyes. Sand-lime brick made with Baguio material has a very pleasing buff color and a high compressive strength. The success that sand-lime brick construction is having in Germany and in the United States is a good indication of the commercial possibility of manufacturing this product in the Philippines.

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COAL

By LEOPOLDO A. FAUSTINO

Distribution.—There is some coal on practically all of the larger islands of the Archipelago and in a majority of the provinces, but in commercial quantities it occurs in only seven of the forty-eight provinces. Table 1 shows the area of coal-bearing formations in the several provinces and the estimated tonnage.

TABLE 1.—*Estimate of areas and tonnage of Philippine coal fields.*

Coal field and province.	Area of coal-bearing formations.	Probable production.	Tonnage.
	Sq. km.	*Per cent.*	*Metric tons.*
Batan Island, Albay	34	50	5,800,000
Cebu Island, Cebu:			
Cajumayjumayan	6	50	2,500,000
Compostela-Danao	42	25	3,400,000
Uling	14	50	2,400,000
Sibuguey (Malangas), Zamboanga	51	20	3,400,000
Sugud Bay, Sorsogon	16	30	1,600,000
Polillo Island, Tayabas	18	15	1,000,000
Cataingan, Masbate	5	10	200,000
Bulalacao, Mindoro	9	25	800,000
Total	195		21,100,000

Smaller areas are not included in the table. In some cases little is known of them, in others small outcrops have been discovered and revocable permits (license to prospect) have been issued, while in one or two cases the area, although fairly large under present conditions, for various reasons cannot be classed as commercial. The case of the deposit in Cagayan Valley in northern Luzon is cited. The coal-bearing rocks of this field are estimated to cover an area of about 6 square kilometers, but the quality of the coal is such that steamers calling at the northern ports of Luzon have not found it desirable to use it.

Geologic occurrence.—The coal-bearing formations of the Philippine Islands are of Tertiary age and for the most part belong to the Oligocene period. The coal-bearing rocks are made up largely of sandstones and shales, locally, with a large percentage

of conglomerate. The characteristic zone fossil is *Vicarya callosa* Jenkins, a brackish-water form, which has been found in most of the fields in the formations in the roof of the coal beds. Marine fossils have also been found. A foraminiferal limestone containing large-sized *Lepidocyclina* occurs in patches over the coal measures.

The coal basins are small and discontinuous and of irregular outline. This is to be expected on account of the peninsular and archipelagic conditions which existed during the coal-forming period. The seams are generally folded and faulted, sometimes intruded by igneous rocks or covered by flows. There are four minable seams in most of the fields, although as many as eight seams have been penetrated by some of the drill holes. The seams now being mined are from 0.3 to 2.5 meters in thickness, although seams having a thickness of 4.5 meters and even 8 meters are known. The dip varies from almost horizontal to nearly vertical. In general, the seams lie at more than 10°.

Character of coals.—The coal fields contain lignite (brown), subbituminous (black), and bituminous coals. The separation of lignites from subbituminous coals is made on the basis of color, the former being brown and the latter black, as proposed by Campbell.[1]

The manner of weathering is recognized as the criterion for separating the subbituminous from the bituminous grade of coal, the irregular breaking in subbituminous coal as opposed to cleaving in prisms in bituminous coal, and the separation along bedding planes into plates in subbituminous coal. The so-called semianthracite of the Sibuguey (Malangas) field is not really semianthracite, as generally understood; it is merely a high-carbon bituminous coal and approaches more the character of semibituminous coal. Table 2 shows analyses of representative Philippine coals and of some of the imported coals.

The lignites are found in areas which are least disturbed and at those places away from the lines of uplift. The subbituminous and bituminous coals occur in the areas of diastrophism and vulcanism or where the lateral disturbances and pressure which folded the formation have produced changes in the character of the coal. The lignites show a distinct woody structure. The subbituminous coals weather very irregularly and, if the process were allowed to continue, the resultant heap would be composed of small fragments of irregular shapes, bounded by

[1] Practical classification for low-grade coals, Econ. Geol. 3 (1908) 134–142.

TABLE 2.—*Analyses of Philippine and imported coals.*

[Analyses by the Bureau of Science.]

Air-dried basis.	East Batan.	Liguan.	Uling.	Butong.	Japan.[a]	Australia.[b]
Proximate analysis:						
Moisture	18.32	5.81	13.98	5.23	6.70	1.84
Volatile matter	36.53	39.39	44.64	14.72	41.94	41.84
Fixed carbon	36.60	49.71	35.07	64.92	43.37	48.80
Ash	8.55	5.09	6.31	15.13	7.99	7.52
Ultimate analysis:						
Sulphur	1.02	0.12			0.68	1.13
Hydrogen	5.32	5.08			7.49	6.55
Carbon	51.55	68.14			63.69	73.73
Nitrogen	0.92	1.11			1.55	2.23
Oxygen	32.64	20.56			18.54	8.68
Calorific value, determined:						
Calories	4,618	6,358	5,840	6,748	6,643	7,558
British thermal units	8,312	11,444	10,512	12,146	11,957	13,604

[a] Fushun coal. [b] Abermain.

rough faces instead of by cleavage planes. The bituminous coals are black, with a shining luster, hard, and have a more or less cubical fracture. Considerable difficulty is experienced in storing the lower-grade coals, on account of spontaneous combustion.

The coals are generally noncoking, although some soft coking coals have been found at Gotas in the Sibuguey field in Mindanao, and at Guila-Guila, Mount Uling, and Toledo in Cebu.

Development, production, and markets.—Although coal was discovered in the Philippine Islands in 1827, or about one hundred years ago, the amount of actual mining has been insignificant. The total number of metric tons of coal produced during the last one hundred years does not exceed 500,000. The present development of the different coal fields mentioned in Table 1 will be briefly described.

The Batan field includes the whole of Batan Island, off the coast of Albay Province. Four seams are mined in this field and they range in thickness from 0.3 to 1.7 meters. Development and production are in progress at its western end, where the Liguan Coal Mines, Inc., has its mines and workings, and at its eastern end where A. U. Betts has driven several tunnels and the Philippine National Bank has two leases. The central portion is idle, although Maks Coal Mining Company of Naga, Camarines Sur, successor to Strittmatter-Karolchuck, has a lease in the Calanaga district.

The Cebu field includes several well-known coal districts in Cebu Island. The Compostela-Danao district is located around Camansi and Mount Licos, west of the towns of Danao and

Compostela, on the east coast of Cebu. The Danao Coal Mining Company is doing development work and has a small production from its mines and workings at Camansi. The National Coal Company was working at Mount Licos but lately suspended operations, presumably from lack of minable coal, and has dismantled and shipped all its mining equipment to Malangas, Mindanao. There are four minable seams in this district varying in thickness from 0.5 to 1.6 meters. Adjoining the Compostela-Danao district to the north is the Cajumayjumayan Valley. This district has four seams of minable thickness, from 0.5 to 3.75 meters, but on account of the difficulties of transportation it has never been developed. The Uling district is in the vicinity of Mount Uling, west of the town of Naga. There are five seams in this district, varying from 0.3 to 4.5 meters in thickness. The Uling-Naga Coal Company at Mount Uling and the Toledo-Cebu Coal Mines near Toledo are the two main producers. Prospecting by drilling was started on Mount Uling by the Cebu Portland Cement Company in 1925 but, after the first three holes, the project was abandoned for lack of funds.

The Sibuguey field includes the whole of Sibuguey Peninsula in Zamboanga Province. There are three seams of minable thickness varying from 0.3 to 2.5 meters. The field is under the control of the National Coal Company. The mines and workings are in Butong, Gotas, Lumbog, and Camp Wilmot districts. The field was tested by diamond drilling, but the data brought forth by the drills have never been interpreted.

The rest of the fields are idle. The Sugud field, located in the southeastern part of Luzon on Sugud Bay in Sorsogon Province, has three minable seams from 3 to 8 meters thick, but no development has been done since 1874. The Polillo field, located near the town of Burdeos in the eastern central part of Polillo Island, Tayabas Province, also has three seams of minable thickness, from 0.6 to 1.5 meters, but has had no development since 1907. The Cataingan field, in the southeastern part of Masbate Province, was abandoned about 1895. It has three seams of sufficient thickness to be mined, varying from 0.7 to 2 meters. The Bulalacao field, located in the southern part of Mindoro, has apparently six minable seams varying from 1 to 4 meters in thickness, but has never had any development.

The production of the three principal fields, in tons of 1,016 kilograms, during the last three years was as shown in Table 3.

TABLE 3.—*Coal production at Cebu, Batan, and Sibuguey in 1923, 1924, and 1925.*

[In tons of 1,016 kilograms.]

Year.	Cebu.	Batan.	Sibuguey.	Total.
1923	20,534	7,520	14,708	42,762
1924	27,242	10,394	9,547	47,183
1925	23,033	10,113	14,766	47,912

The principal coal markets of the Philippine Islands are Manila, Cebu, Iloilo, and Zamboanga, and practically all the coal produced and imported is disposed of in those ports. The coal production is barely sufficient to meet the demand, and great quantities are imported from Japan, China, Australia, and the East Indies every year. The heaviest consumers of coal in the Philippines are the railroads, the interisland steamers, and the industrial plants. Table 4, compiled from the Annual Reports of the Collector of Customs, shows the coal importation into the Philippine Islands for 1924 and 1925.

TABLE 4.—*Coal imported into the Philippine Islands in 1924 and 1925.*

Country of origin.	1925		1924	
	Tons of 1,016 kg.	Value.	Tons of 1,016 kg.	Value.
		Pesos.		*Pesos.*
United States	27.04	858	30,237.59	378,809
United Kingdom	----------	----------	5.00	75
China	5.62	51	18,874.84	179,804
Japanese China	198,878.39	1,656,782	100,356.57	1,020,504
British East Indies	2,987.00	27,396	3,035.00	41,998
Dutch East Indies	18,178.00	204,135	4,998.00	48,639
French East Indies	----------	----------	46,435.00	280,276
Japan	134,501.35	1,275,449	123,523.18	1,209,491
Australia	107,893.16	1,119,356	136,170.50	1,295,988
British Africa	----------	----------	8,508.30	125,931
Total	462,470.56	4,284,027	472,143.98	4,581,515

At the close of the calendar year 1925 there were only six coal operators producing coal in marketable quantities, although a great number of revocable permits and leases was in force during the year. The following are the coal operators who produced coal in greater or less quantities during the calendar year 1925.

A. U. Betts.
Danao Coal Mining Company.
Liguan Coal Mines, Inc.
National Coal Company.
Toledo-Cebu Coal Mines.
Uling-Naga Coal Company.

The following is a list of holders of coal revocable permits and coal leases in 1925:

List of coal revocable permits and coal leases in force, December 31, 1925.

[From Bureau of Lands, Manila.]

COAL REVOCABLE PERMITS.

No.	Permittee.	Address.	Location.
1	Pedro P. de Garcia	Naga, Cebu	Naga, Cebu.
1	Edgar D. Cummings	Toledo, Cebu	Toledo, Cebu.
4	Isidoro N. Enriquez	P. O. B. 5, Cebu	Do.
5	Federico B. Sarabia	42 Escolta, Manila	Buruanga, Capiz.
8	Apolinar Abella	Cebu, Cebu	Minglanilla, Cebu.
9	Manuel Enriquez	217 C. Padilla, Cebu	Toledo, Cebu.
10	Juan Ariate	c/o Attorney Rafols, Cebu, Cebu.	Do.
12	Eugenio Enriquez	1 Inanalili, Cebu	Do.
13	Teofilo Libre	c/o Attorney Rafols, Cebu, Cebu.	Do.
18	Teofilo Rivera	Naga, Cebu	Naga, Cebu.
22	Martiniano Evangelista	Toledo, Cebu	Toledo, Cebu.
23	Mamerto A. Engbino	Minglanilla, Cebu	Do.
27	Monico Adlawan	Talisay, Cebu	Do.
28	Rosario N. Gonzales	1966 O'Donnell, Manila	Buruanga, Capiz.
29	Inocenta Jimenes	42 Escolta, Manila	Do.
32	Paulino Maatuban	Buruanga, Capiz	Do.
35	Aquilina Codilla	128 Colon, Cebu	Cebu, Cebu.
38	Mariano Yap	Toledo, Cebu	Toledo, Cebu.
42	Arcadio Jaca	Pardo, Cebu	Do.
40	Vicente Canonigo	Naga, Cebu	Naga, Cebu.
44	Teofilo Chiong	38 C. Padilla, Cebu	Toledo, Cebu.
47	Luis Belleza	Naga, Cebu	Naga, Cebu.
48	Ambrosio Natad	172 Sansiangko, Cebu	Do.
49	Moises Veloso	Naga, Cebu	Naga, Cebu.
53	Angel Yriarte	Cebu, Cebu	Toledo, Cebu.
54	Juan Pardillo	Minglanilla, Cebu	Do.
55	Anastasio S. Rama	100 Pelaez, Cebu	Do.
56	Antonio Juarez	Talisay, Cebu	Do.
57	Agustin Y. Kintanar	139 Juan Luna, Cebu	Naga, Cebu.
58	Alberto Villabir	Minglanilla, Cebu	Toledo, Cebu.
60	Guillermo Villanueva	Bais, Oriental Negros	Manjuyod, Oriental Negros.
61	Martin Silgas	Minglanilla, Cebu	Naga, Cebu.
63	Marciano Abarquez	Talisay, Cebu	Toledo, Cebu.
65	Restituto Villordon	Minglanilla, Cebu	Do.
66	Hilario Toledo	Danao, Cebu	Danao, Cebu.
67	Vicente Villarino	....do	Do.
69	Pedro Alforque	Camp 4, Talisay, Cebu	Toledo, Cebu.
70	Constancio Tenchavez	Cebu, Cebu	Do.
75	Jacinto Daclan	Naga, Cebu	Naga, Cebu.
76	Fidel Natad	172 Sansiangco, Cebu	Dalaguete, Cebu.
77	Pedro Caballero	129 Sansiangco, Cebu	Do.
78	Manuel Tan	Minglanilla, Cebu	Naga, Cebu.
80	Josefina Gonzales	197 Martires, Cebu	Toledo, Cebu.
81	Primitivo Abarquez	12 Tupas, Cebu	Do.
82	Quintin Rivera	Naga. Cebu	Do.

List of coal revocable permits and coal leases in force, December 31, 1925—Continued.

COAL REVOCABLE PERMITS—Continued.

No.	Permittee.	Address.	Location.
85	Serapio Baylon	Candelaria, Zambales	Sta. Cruz, Zambales.
86	Perfecto M. Alejo	503 Malabon, Manila	Do.
87	Roman Eamilao	Masinloc, Zambales	Do.
88	Juan G. Roque	San Miguel, Bulacan	Angat, Bulacan.
89	Clemente Roque	do	Do.
90	David S. Rivera	10 Tres de Abril, Cebu, Cebu	Toledo, Cebu.
91	Mariano M. Farrales	Iba, Zambales	Sta. Cruz, Zambales.
92	Buenaventura Ebancuel	Masinloc, Zambales	Do.
93	Nicolas Ecobisag	do	Do.
94	Mateo E. Perez	do	Do.
95	Basilia Cabanada	171 Tres de Abril, Cebu, Cebu	Cebu, Cebu.
96	Juan Abella	do	Do.
97	Modesta Sasan	Tuyan, Naga, Cebu	Toledo, Cebu.

COAL LEASES.

No.	Lessee.	Address.	Location.
2	Philippine National Bank	Manila	Batan Island, Rapu-rapu, Albay.
3	Uling Naga Coal Company	Cebu, Cebu	Mount Uling, Naga, Cebu.
4	Strittmatter-Karolchuck Coal Mining Company.[a]	Legaspi, Albay	Batan Island, Rapu-rapu, Albay.
5	Danao Coal Mining Company	Cebu, Cebu	Camansi, Danao, Cebu.
6	Liguan Coal Mines, Inc	203 Roxas Building, Manila	Batan Island, Rapu-rapu, Albay.
7	J. Clayton Nichols	P. O. B. 389, Cebu	Toledo, Cebu.
8	Philippine National Bank	Manila	Batan Island, Rapu-rapu, Albay.

[a] Coal Lease No. 4 of Strittmatter-Karolchuck Coal Mining Company was transferred by the lessee to Maks Coal Mining Company of Naga, Camarines Sur, approved by the Secretary of Agriculture and Natural Resources on November 17, 1925.

GYPSUM

By Antonio D. Alvir

The most important gypsum locality in the Philippine Islands is near the barrio of Talahib, Toboo, Batangas Province. In 1924, 1,360 tons of gypsum were produced valued at 25,848 pesos, and in 1925, 1,704 tons valued at 42,066 pesos. The entire production was sold to the Cebu Portland Cement Company, which company used it exclusively until recently, when it stopped buying the gypsum, the reason given being that the last shipments were of a poor grade. Gypsum is still mined in Batangas, but the product is crushed and pulverized for use as fertilizer. About 200 tons of pulverized gypsum are at present available for shipment.

The Talahib deposits are owned by the Philippine Gypsum Mining Corporation, composed entirely of Filipinos. This Corporation has exploited these deposits since 1916 when the Rizal cement plant at Binangonan, Rizal, was operating. When the company failed in 1919, work on the gypsum deposits also stopped. With the beginning of operations in the Cebu cement factory in 1923, mining in Talahib was resumed. The recent demise of the president and largest stockholder of the corporation, Mr. V. Argüelles, has caused a temporary halt in the operations.

The deposits are in the form of vertical, somewhat irregular, fissure veins from a few inches to several feet in width. The wall rock is andesite, which near the vein is altered and heavily permeated with gypsum. A sample of gypsum taken from the Pantaleon Mine showed chalcopyrite, covellite, and chalcocite, with a little pyrite. This discovery may lead to a possible explanation of the origin of the gypsum veins.

The mineral is mined by stripping the veins without proper supports. Cave-ins in the Pantaleon mine have occurred, fortunately without casualties. This particular mine, from which most of the production has come, has now been abandoned because of the danger from cave-ins. Other deposits in the neighborhood have been opened up; the most important are the Calauang and the Segovia. The greater part of the work has

been concentrated at Calauang, a short distance from the Pantaleon. A small temporary tramway has been built from the Pantaleon to the coast about 3 kilometers distant. The mineral mined at Calauang is transported on horseback to the Pantaleon mine, where it is loaded on the tramcars for transportation to the coast.

Very little real development has been done on any of the deposits mentioned. It has been the policy to produce as much gypsum as can be easily mined without giving any consideration to the future of the mine. There were no funds available for development work. The extent and the depth of the veins are consequently unknown, and no data are available regarding the quantity of gypsum present.

Other deposits of gypsum similar to those of Talahib are found in Mabini and in Bauan, also in Batangas Province. No work has been done on either of these deposits. A vein in Mabini is reported to be 50 feet wide.

Reports reaching the Bureau of Science claim the existence of large gypsum deposits in Olutanga Island, Zamboanga Province. The reports have not yet been verified, but the samples submitted have been identified as crystals of gypsum.

LIME

By LEOPOLDO A. FAUSTINO and F. D. REYES[1]

TABLE 1.—*Production of lime in 1924 and 1925, by provinces.*

Province.	1924		1925	
	Metric tons.	Value.	Metric tons.	Value.
		Pesos.		*Pesos.*
Abra	19	380	18	360
Albay	109	4,360	122	4,880
Antique	12	460	17	680
Bataan	1,500	1,500	1,500	1,500
Batanes	560	11,200	594	11,875
Batangas	513	9,183	568	10,662
Bohol	4	102	4	102
Bulacan	408	7,614	394	7,411
Cagayan	3	75	3	33
Camarines Norte			55	548
Camarines Sur	50	500		
Capiz	15	255	15	255
Cavite	20	280	20	280
Cebu	3,862	11,086	4,188	12,295
Ilocos Norte	193	1,926	286	2,289
Ilocos Sur	549	4,312	694	5,401
Iloilo	1,065	50,845	2,717	130,107
Laguna	5	200		
La Union	237	2,370	237	2,370
Marinduque	3	125	3	125
Mountain	10	150	65	972
Occidental Negros	78	775	99	988
Oriental Negros	10	80	10	80
Pangasinan	26	765	26	772
Rizal	2,323	27,556	2,323	27,556
Samar	5	525	6	599
Tayabas	2,103	114,873	2,678	148,700
Zambales	5	195	5	215
Total[a]	13,759	252,992	16,721	372,705

[a] Includes estimate of unreported production from other provinces.

The production figures for lime given in Table 1 are as reported by the provincial treasurers; and, while they are the best figures available, the statistics do not show the status of the industry except in a general way. The figures are a little low for some provinces, and the unit price per metric ton varies from 1 peso in Bataan and about 50 pesos in Iloilo and Tayabas to more than 100 pesos in Samar. The production in the City of Manila, estimated at about 2,250 metric tons a year valued

[1] Chief, division of general, inorganic, and physical chemistry, Bureau of Science.

60,000
at ~~6,000~~ pesos, has not been included in the table. The bulk of low-grade lime sold in the city for mortar purposes is produced in Tondo district, near Manila Bay.

The two most important sources of lime in the Philippines are the limestone quarries and oyster and other marine shells. Although twenty-eight of the forty-eight provinces are producers of lime, the production does not meet the demand, either in quantity or quality. Since 1912 the demand for a better grade of lime has been insistent, both for construction purposes and for sugar manufacture. With increased sugar production the demand for high-grade lime suitable for chemical purposes has been such as to require importation from the United States. The most important lime-producing provinces are Tayabas, Iloilo, Rizal, and Cebu, and also the City of Manila.

The making of lime from sea shells is notably developed in Malabon and Navotas in Rizal Province on Manila Bay, due in large measure to the presence of oyster beds in that locality. About 1,800 tons of slaked lime are burned annually in Malabon and Navotas. The raw material is furnished for the most part by oyster shells and, as these are poorly cleaned, the yield is an impure product. In some of the kilns spent tanbark is used for fuel. In the Tondo district of Manila there are three or four limekilns, in which other marine shells (*Arcas, Lucina,* etc.), obtained from the fishery beds in Bulacan Province, are used, and the fuel is coke of a very impure grade. The general practice among the operators is to mix six parts of shells to one part of fuel. These kilns have an estimated annual production of about 2,250 metric tons, and they supply the low-grade lime requirements of the different construction works in the City of Manila. Some of the better-grade product is shipped to Bataan for use in the sugar central.

The following analysis of burned shell taken from a Gagalangin (Tondo) limekiln will be of interest:

Constituent.	Per cent.
Total calcium oxide (CaO)	61.4
Carbon dioxide (CO_2)	14.5
Clay, sand, etc.	24.1
	100.0
Calcium carbonate ($CaCO_3$)	[a] 32.9
Calcium oxide in calcium carbonate (CaO in $CaCO_3$)	18.4
Total impurities ($CaCO_3$ + sand, clay, etc.)	57.0
Available lime (CaO)	[a] 43.0

[a] Estimated.

Pure, hard limestones, argillaceous limestones, and marl, or chalk, are widely distributed throughout the Archipelago. These are quarried and calcined in kilns, and a better grade of lime than that from sea shells is produced.

The simplest type of kiln is a hole in the ground in which the limestone and wood are placed. A more-developed process uses a forced draft, and a better grade of product is obtained.

In some places lime manufacture is very highly developed. In Baguio, for example, large kilns are built of limestone. Fuel and rock are kept separate, in order that there should be no contamination of the lime with the ashes. The kilns, being made of limestone as fire brick is not available, are relined from time to time. These kilns cannot be operated continuously, and considerable fuel and labor are wasted. The better-known quarries and kilns are on the northern shore of Tayabas Bay in Tayabas Province, Guimaras Island, Iloilo Province, Binangonan, Rizal Province, and in Moutain Province.

The composition of some of the Philippine limestones will probably be of interest to those interested in the lime industry, and the analyses are given in Tables 2 and 3.

TABLE 2.—*Analyses of some Philippine limestones.*

[Numbers give percentages.]

Constituent.	Cebu.	Binangonan, Rizal, 1912.[a]	Binangonan, Rizal, 1918.	Montalban, Rizal, 1912.[a]	Montalban, Rizal, 1918.	Palsabangan, Tayabas.[b]
Loss on ignition	43.45	43.31	43.49	43.04	43.98	43.48
Silica (SiO_2)	0.86	1.12	0.88	0.94	0.26	0.69
Iron and aluminium oxides (R_2O_3)	0.23	0.15	0.48	1.14	0.09	0.35
Lime (CaO)	54.67	53.78	54.39	54.61	54.97	54.68
Magnesia (MgO)	0.46	1.19	0.68	0.22	0.72	0.48
Alkalies (K_2O+Na_2)		0.77		0.56		

[a] Analyzed by Forest B. Beyer. [b] Analyzed by F. D. Reyes, chemist, Bureau of Science.

TABLE 3.—*Analyses of limestones, showing magnesia (MgO) content.*[a]

Source.	Magnesia, per cent.
Tacay, Guimaras	0.63
Taminla, Guimaras	9.87
Danguil, Guimaras	15.07
Pagatpat, Guimaras	7.20
Isla de Gigante	0.85

[a] Analyzed by Francisco Peña, chemist, Bureau of Science.

It will be noted that the undesirable magnesia content is present in small amounts in some of the limestones from Guimaras,

and that the sample from Gigante Island is satisfactory. The entire limestone deposit at Gigante Island is of the same character and it has the added advantage of being near deep water, where boats can load quantities of material for transportation to the lime kilns.

The Bureau of Science has been conducting calcination tests on Philippine limestones and has been able to obtain satisfactory results. A lime-burning test made during the period from November 28 to December 9, 1916, using Binangonan limestone and a good grade of bituminous coal with natural draft, resulted in an average fuel-to-lime ratio of 1 part by weight of coal to 2.3 parts by weight of lime. During a six-day run the kiln produced a total of 11,604 kilograms of lime, which is equivalent to 1,934 kilograms of lime, or nearly 2 metric tons, every twenty-four hours, the underburned lime amounted to 1,866 kilograms, or about 16 per cent. All of the limestone charged passed a 5-inch ring and nothing was fed into the kiln smaller than would pass a 3-inch ring. The kiln has a maximum shaft diameter inside of 3 feet 8 inches, and a total height from base of cooling zone to charging level of 13 feet 7 inches. A similar kiln, 6 feet in diameter, has been capable of producing between 4 and 5 metric tons a day.

Calcination tests performed on Palsabangan limestone, using air-dried bacauan wood for fuel and burned with a natural draft, gave a fuel-to-lime ratio of 0.76 to 1. In other words, 760 kilograms of wood calcined 1,000 kilograms of lime. With coconut shells as fuel the yield of lime was less, 850 kilograms of shells burning 1,000 kilograms of lime.

The results here discussed are presented in Table 4.

TABLE 4.—*Calcination tests on limestone from Tayabas Province.*

Fuel.			Lime.
Kind.	Volume.	Weight, air-dried.	
	cu. m.	*kg.*	*kg.*
Mountain wood	1.55	852	1,000
Bacauan (raja)	----------	760	1,000
Coconut shells	----------	850	1,000
Fushun coal	----------	435	1,000

The important uses of lime in the Philippines are in the clarification process of sugar manufacture, in the making of mortar for building operations, and in tanning leather.

MINERAL WATERS

By JOSE M. FELICIANO[1]

The term mineral water, as defined by W. D. Collins of the United States Geological Survey, is rather too limited in its scope. His definition reads as follows:

> Water that is bottled and sold in its natural state or only slightly altered from its natural state. It includes (a) natural carbonated waters that have lost part of their carbon dioxide; (b) natural waters that have been artificially carbonated; and (c) waters from which iron has been removed.

This term should include waters having (*a*) a high content of soluble matter; (*b*) a high content of rare or unusual substances; and (*c*) high temperature.

The three uses of mineral waters are for table, for medicinal purposes, and the manufacture of soft drinks. The medicinal use of mineral water should include its use for bathing and washing purposes. The thermal waters which are now accepted as mineral waters are of special use for the so-called hydrotherapy in medicine.

The Philippine Islands is a country rich in mineral springs and mineral waters, distributed from Luzon in the north to Mindanao in the south. Practically in all of the large islands of the Philippine Archipelago there are springs known by the people to possess some curative value. The waters of some springs have not been analyzed for determining definitely the mineral substances present. In some cases, where analysis has already been made, the waters are found to be of no medicinal value. In the majority of cases, however, they are found to contain chemical substances that possess some therapeutic properties. Again, there are a few natural springs in the Philippines that are radioactive and, therefore, of some medicinal value. Such waters, however, cannot be kept for a long time, as the radioactive substances disintegrate very rapidly.

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[1] Acting head, department of geology and geography, University of the Philippines.

The consumption of mineral waters in the Philippine Islands is shown in Table 1.

TABLE 1.—*Consumption of mineral waters in the Philippine Islands in 1924 and 1925.*

Year.	Imported.		Local production.	
	Liters.	*Pesos.*	*Liters.*	*Pesos.*
1924	449,539	158,636	188,056	68,161
1925	358,802	120,197	209,861	78,223

From the above figures we can see that the annual consumption of mineral waters in the Philippines is about 200,000 pesos and that only one-third of the water consumed is manufactured and produced locally. The importation of this product can be reduced to the minimum by proper exploitation of the local supply.

The mineral waters and mineral springs now known in the Philippines may be classified according to the mineral substances they contain, as follows:

I. Thermal.
Examples: (1) Jigabo Springs, Tiwi, Albay; (2) Mainit Spring, Bontoc, Mountain Province; (3) Los Baños Spring, Laguna.

II. Carbonated (or bicarbonated).
1. Alkaline, containing:
(*a*) Sodium bicarbonate.
Examples: (1) San Raymundo Spring (Calauan), Lemery, Batangas; (2) Masingal Spring, Masingal, Ilocos Sur.
(*b*) Potassium bicarbonate.
Example: Dinalupihan Spring, Bataan.
2. Alkaline earth, containing:
(*c*) Magnesium, containing:
(*a*) Magnesium bicarbonate.
Examples: (1) Gapas Spring, Balayan, Batangas; (2) Hot Spring, Puerto Galera, Mindoro.
(*d*) Calcium, containing;
(*a*) Calcium bicarbonate.
Examples: (1) Bolocboloc Spring, Barili, Cebu; (2) Spring of San Mariano, Pozorrubio, Pangasinan.

III. Chalybeate (ferruginous).
Containing the sulphate and bicarbonate of iron.
Examples: (1) Lanot Spring, Daet, Camarines Norte; (2) Badukbuk Solfatara, Daklan, Benguet, Mountain Province.

IV. Chloride waters.
Containing salts, mainly sodium or potassium chlorides.
Examples: (1) Pasacao Spring, Pasacao, Camarines Sur; (2) Naglabong Spring, Tiwi, Albay.

V. Sulphated waters.
Containing sodium sulphate.
Examples: (1) Spring of Cabab, Angaqui, Lepanto, Mountain Province; (2) Klondike Spring, Benguet, Mountain Province.

VI. (1) Containing bromides of sodium.
Example: Cotabato Spring, Cotabato, Mindanao.
(2) Containing bromides and iodides.
Example: Napundut Spring, Rosales, Pangasinan.

VII. Sulphuretted waters.
Containing hydrogen sulphide.
Example: Sibul Spring, San Miguel de Mayumo, Bulacan Province.

VIII. Arsenical.
Containing arsenic.
Example: Tiwi Spring, Albay.

IX. Lithia.
Containing lithium salts.
Example: Napundut Spring, Rosales, Pangasinan.

The above list shows that almost all kinds of mineral waters that are now imported can be produced locally. In many of the places sanatoria can be established, and advantage taken of the beautiful scenery and prevailingly cooler climate, as well as of the medicinal properties of the water from the mineral springs. In most cases the mineral springs are also thermal, so that hot- and cold-water bathing would also be available.

Table 2 gives a comparison of chemical analyses of imported mineral waters and of Philippine mineral waters. The letters at the head of the columns are explained as follows:

A. The Grande-Grille, Vichy, France. Analysis by J. Bouquet, Annales Chim. Phys. III 42 (1854) 304.
B. Lalo Spring, Goa, Camarines Sur. Analysis by Anacleto del Rosario y Sales. M. D. de los Manantiales de la Isla de Luzon, Jose Centeno (1890) 16 pp.
C. The Sprudel, Carlsbad, Bohemia. Analysis by F. Ragsky, cited by Roth, Allgemeine und Chemische Geologie, 1, 569.
D. Balong Anito Spring, Mariveles, Bataan. Analysis by George W. Heise and A. S. Behrman. Philippine Water Supplies, 142.
E. Tansan, Mineral Water (imported). Analysis by R. Aguilar.
F. Isuan, Mineral Water (bottled in Los Baños). Analysis by R. Aguilar.
G. "Red Roc" Mineral Water (imported). Analysis by Rafael Aguilar.
H. Sibul Spring, San Miguel de Mayumo, Bulacan. Analysis by George W. Heise and A. S. Behrman. Philippine Water Supplies, 142.

TABLE 2.—*Chemical analyses of imported mineral waters and of Philippine mineral waters.*

[Parts per million of water.]

	A	B	C	D	E	F	G	H
Chlorine (Cl)	324	422.5	625.5	670	277	367.5	450	24.6
Iodine (I)			Trace					
Fluorine (F)			1.63					
Sulphate (SO_4)	197	94.4	1,693.9	1,400	14.4	26.99	4.5	4
Sulphur (S)								
Carbonate (CO_3)	2,392	1,651	1,040	1,001				
Carbonic acid (H_2CO_3)					80	191.54	170	
Phosphate (PO_4)	80	Trace	0.5					
Arsenate (ASO_4)	2							
Boron heptoxide (B_4O_7)			Trace			Trace		
Sodium (Na)	1,851	[a] 282.7	1,764.5	529		198.2		23.30
Potassium (K)	151		73.3	54		30.8		1.30
Lithium (Li)			Trace	0.86		0.24		
Calcium (Ca)	120	[c] 221.7	121.11	640	32.4	90.35	4	148.90
Strontium (Sr)	2		0.5					
Magnesium (Mg)	58	[b] 205.5	35.3	110	1.3	19.30		14.92
Manganese (Mn)		Trace						
Iron (Fe)			1.08	Trace	1.18		0.52	
Ferric oxide (Fe_2O_3)	2	39			[d]	[d]		[d]
Aluminium trioxide (Al_2O_3)		Trace		29.6	8.4	1.25		0.60
Silicon dioxide (SiO_2)	70	117.6	72.77	140	24.4	161.4	15	41
Nitrate (NO_3)						1.195		
Ammonium (NH_4)						0.023		
Oxygen gas (O_2) to form ferric oxide (Fe_2O_3)						42.83		
Aluminium (Al)					3.56		50	
Total	5,249	2,960	5,431	4,200	596		980	498

[a] Arsenic sodium oxide as Na_2O.
[b] Arsenic magnesium oxide as MgO.
[c] Arsenic calcium oxide as CaO.
[d] Arsenic ferric oxide as Fe_2O_3 and aluminium trioxide (Al_2O_3).

PETROLEUM

By LEOPOLDO A. FAUSTINO

The Philippine Islands has not produced oil in commercial quantities. An insignificant amount has been taken from shallow wells and seepages, and has been used for lighting and medicinal purposes, but nothing approaching commercial production has been possible. The search for favorable structures has been more or less abandoned, at least temporarily, and all drilling leases have been surrendered to the Government. The failure of the Richmond Petroleum Company, a subsidiary of the Standard Oil Company of California, to strike oil in commercial quantities in Bondoc Peninsula, Tayabas Province, has had a very depressing effect on the industry. At the close of the calendar year 1925 exploration and development in all the more important oil fields were at a standstill.

The following are the localities known to contain oil and which are considered worthy of exploration and development:

Bondoc Peninsula, Tayabas Province.
Northwestern part of Leyte.
Central Panay.
Toledo, Cebu.
Southern part of Mindoro.
Pidatan district, in central Mindanao.

The Tayabas oil field includes that portion of Bondoc Peninsula, Tayabas Province, south of the towns of Catanauan and San Narciso, or approximately the southern half of the peninsula. The extent of this field is indicated by seeps which are found in highly inclined strata. The petroleum occurs, associated with certain horizons, in an extensive series of beds of sandstone and shale (Vigo shale). The principal seeps are found in the upper part of this series, which is predominantly shale, but contains subordinate beds of sandstone.

Several shallow wells have been drilled in this field, three of which have produced petroleum in small quantities by pumping. These have never been pumped for any length of time, partly on account of lack of storage facilities, and it is not known how much petroleum can be obtained by continuous pumping, or whether enough petroleum is accumulating at the bottom of the wells to keep the pumps busy. It is claimed, however, that Banco

wells Nos. 3, 4, and 5, which were drilled in 1918 and 1919, would probably average about one barrel a day. The first well drilled in Bondoc Peninsula was Bahay well No. 1, in 1906. Drilling was done entirely by hand power and reached a depth of 127 feet, and a small quantity of gas and oil was obtained. Drilling by modern methods was started in this field by the Richmond Petroleum Company in the early part of 1921. From 1921 to July, 1924, the company was able to drill four wells. These wells are the following, given in order of their depth:

	Feet.
Yebaan No. 1	617
Amuguis No. 1	1,323
Sapa No. 1	3,757
Pina No. 1	5,117

The Richmond Petroleum Company has drilled a total footage of 10,814. Slight indications of petroleum and natural gas have been encountered, but of oil nothing that even nearly approached commercial quantities was found under the structures tested. The company discontinued drilling activities in July, 1924, and has stored all its field equipment at Manila.

The Leyte oil field includes the extreme northwestern peninsular portion of Leyte Island, as far south as the barrio of Baliti, municipality of Villaba. The seeps are located on the upturned edges of the series of beds of sandstone and shale called the Vigo shale, as in Bondoc Peninsula, Tayabas Province. Residual bitumens are found in the overlying Canguinsa sandstone and have also impregnated the Malumbang limestone series which caps the Canguinsa. This field has never been tested by drilling, although favorable structures have been indicated. Some geologists claim that asphalt deposits of considerable amount indicate that the oils have already escaped; but, on the other hand, we have the case of the grahamite deposit of Ritchie County, West Virginia, in the United States, which occurs at right angles to the direction of the anticlinal fold that is productive of oil.

The Cotabato oil field is situated in the heart of Mindanao and covers an area of unknown extent in the Pidatan district, a short distance south of the Lanao-Cotabato boundary. The only indication of oil in this field is a single seep, which is located in a ravine on the headwaters of Kirusoy Creek, a tributary of Malitubug River. The small amount of oil and gas issues from what appears to be a contact between basaltic igneous rock and agglomerate. An analysis of the oil showed no light constit-

uents such as gasoline, benzene, and kerosene, and only from 1 to 2 per cent of wax, or paraffine residuum. If this analysis be taken as representative, the Cotabato oil must be considered abnormal and one that has lost some of its constituents in migration. It is probable that the oil-bearing rocks in this field are also Vigo shale, as is the case in Tayabas and Leyte.

The Cebu oil field can be considered to extend from the town of Alegria on the western coast of southern Cebu to the town of Toledo on the same coast. Petroleum indications are by a fairly strong seep at the head of Malbog Creek near Alegria and seepages near Toledo. The seeps are located on the upturned edges of beds of shales and sandstones (Vigo shale). This field was tested by drilling when Smith Bell and Company, Limited, of Manila drilled two wells near Iligan, a barrio of Toledo, in 1896. The wells reached a depth of 244 meters (800 feet) and 344 meters (1,128 feet), respectively. Petroleum was encountered and a small amount was produced, but with the coming of the insurrection all work was abandoned. The district has been idle since that time.

The Mindoro oil field is located at the southern end of Mindoro, near Mangarin. Petroleum indications are by a number of seeps emanating from shales and sandstones (Vigo shale) located in small creeks to the northwest of Mangarin. These creeks are tributaries of Bugsanga River. Although geological exploration was carried on in this field, it has never been tested by drilling.

The Panay oil field is situated on the eastern flanks of the main cordillera in the central part of the island. Petroleum indications in this field are in the form of gas emanations which were encountered in Iloilo Province. The Vigo shales are present in this area and the presence of petroleum is not at all improbable. This district has never been tested by drilling, but in 1910 a well was drilled by the Bureau of Public Works for artesian water at Janiuay, Iloilo Province, which reached a depth of 537 meters and emitted gas and salt water intermittently.

Philippine petroleum is light brown to wine red to violet in color. It has a paraffine base, and the paraffine content is usually high. It loses part of its lighter constituents readily upon exposure. The density of the oil ranges from 21 to 38° Baumé. (The density of Oklahoma oil ranges from 22 to 47° Baumé.)

The Philippine Islands has been importing increasing quantities of crude petroleum. In 1924 the total imports amounted to 4,105,819 pesos, and in 1925, to 4,853,587 pesos. Table 1, taken

from the Report of the Insular Collector of Customs, shows the importation of "mineral crude oil" into the Philippine Islands.

TABLE 1.—*"Mineral crude oil" imports into the Philippine Islands in 1924 and 1925.*

Country of origin.	1925		1924	
	Quantity.	Value.	Quantity.	Value.
	bbls.	*Pesos.*	*bbls.*	*Pesos.*
United States	1,117,851.54	3,609,179	1,122,799.89	2,307,071
Dutch East Indies	388,478.55	1,244,408	563,708.19	1,798,748
Total	1,506,330.09	4,853,587	1,686,508.08	4,105,819

In addition gasoline, kerosene, lubricating, and other oils to the amount of 13,105,529 pesos were imported in 1924, and 12,407,486 pesos in 1925. Table 2 shows this importation in detail.

TABLE 2.—*Importation of gasoline, kerosene, and other oils in 1924 and 1925.*

Product.	1925		1924	
	Quantity.	Value.	Quantity.	Value.
	Liters.	*Pesos.*	*Liters.*	*Pesos.*
Gasoline and other motor spirits	48,315,968	5,652,435	38,873,404	4,912,598
Naphthas, other than gasoline	103,808	13,144	181,543	14,850
Illuminating, or kerosene	60,028,279	5,060,180	65,173,701	5,846,168
Lubricating	9,057,243	1,535,275	10,300,961	2,173,857
Residuum, including tar, and all others from which light bodies have been distilled.	1,783,243	146,452	1,549,461	158,056
Total		12,407,486		13,105,529

GUANO AND PHOSPHATE ROCK

By ANGEL S. ARGÜELLES[1]

GUANO

The guano industry has undergone considerable development during the last two or three years, owing to the great demand for commercial fertilizers. The exploitation of guano on a commercial scale requires adequate knowledge of the important phases of the business. A brief discussion on the essential factors to be considered in such exploitation is here given.

Nature of guano deposit.—A guano deposit is a heterogeneous mass of material, consisting largely of the excreta of bats and birds, mixed in varying proportions with débris and earthy materials found in the cave. It is, therefore, essential that a general survey be made of the deposit with special reference to the thickness and colors of the various strata, or layers.

Sampling.—It is important that several representative samples be secured before exploitation of a guano deposit is begun. The following method of sampling is recommended: Samples of guano of the same layer and color should be obtained at different points and at varying depths. They should be obtained at every 2 or 3 meters between points, and at various depths, about 0.5 meter or more, depending upon the thickness of the layer. The change in layer can generally be observed by the change in color and the physical structure of the material. The samples collected from a distinct layer must be thoroughly mixed and quartered. The two opposite quarters must be combined and mixed, and the two other quarters discarded. This process must be repeated until the bulk of the sample is reduced to about 1 kilogram. This should be placed in a container and the latter carefully sealed and labeled. Representative samples from each distinct layer can then be sent to the Bureau of Science for analysis. The commercial value of the guano deposit is based upon its chemical composition.

Exploitation and shipment.—The digging should be supervised and care taken that the guano excavated does not include earthy

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and other materials that are not guano. The guano thus excavated should be stored in a well-aërated shed or barn. Whenever practicable, the guano should be sun-dried in order to reduce the moisture content to the minimum. It has been found that some guanos forwarded to local dealers contain from 25 to 35 per cent moisture. Some dealers impose a penalty when the moisture is in excess of 15 per cent, so that a guano containing 35 per cent moisture in a 100-ton shipment would suffer a reduction of 20 per cent by weight, with the result that only 80 tons would be credited to the seller instead of 100 tons. By proper air- or sun-drying so as to reduce the moisture content to about 15 per cent, the amount allowed, the penalty can be avoided. Reduction in moisture content will also result in reduction in handling and transportation costs. Furthermore, the nitrogen and phosphoric acid content are correspondingly increased, and consequently there will be an increase in the price of the guano per ton. The narrow margin of profit on an ordinary guano makes it necessary to consider carefully the cost of transportation from the place of origin to the market. It is generally considered that a guano deposit more than 0.5 kilometer from the sea or the point of loading is of doubtful commercial advantage unless the material be of exceptionally high quality. It has been the common experience of those engaged in the exploitation of guano that, even though reasonable care has been exercised in taking samples for analysis, the analysis of samples taken from cargoes of guano actually shipped is from 10 to 15 per cent below the analysis of the original sample. This fact should be borne in mind when prices are being calculated.

Price of guano.—At present there is no systematic way of evaluating guano. However, certain local manufacturers pay 5 pesos for every per centum of nitrogen and 1 peso for every per centum of phosphoric acid, and deduct weight for moisture in excess of 15 per cent. This is illustrated by supposing that the sample contains 2 per cent nitrogen, 15 per cent phosphoric anhydride, and 35 per cent moisture. The price of nitrogen per ton of guano would be 10 pesos, and for the phosphoric anhydride 15 pesos, or a total of 25 pesos per ton. Since the moisture content is 35 per cent, or 20 per cent above the maximum allowed, a reduction of 20 per cent in the tonnage is made; that is, if 100 tons of this guano have been supplied, only 80 tons will be credited to the seller. This is equivalent to 2,000 pesos for the 100-ton shipment, instead of the 2,500 pesos which would have

been received had no penalty been incurred for excess moisture content. This practice is not quite fair, unless the percentages of the nitrogen and phosphoric acid are also calculated on the basis of 15 per cent moisture, for a decrease in moisture causes a corresponding increase in the nitrogen and phosphoric anhydride contents. Furthermore, it is often the practice to utilize the guano as received and to mix it as such with the various fertilizer ingredients to make commercial fertilizers. An allowance of 20 per cent moisture for guano instead of 15 per cent would approximate actual conditions. In this case, it would only be fair to calculate the percentages of the constituents on the basis of 20 per cent moisture rather than as received.

Submitting samples for analysis.—In view of the fact that the evaluation of guano is based upon the percentage of the essential constituents and moisture contents, it is absolutely essential that a representative sample be taken. In order to avoid controversy, it would be desirable that the buyer and the seller be represented at the time of sampling, and they should agree upon the sample to be submitted for analysis, or else they may agree on a third person who will obtain the samples for them. It is essential, of course, that the sample be taken out of every fifth or tenth sack, and that the partial samples so secured be thoroughly mixed, quartered, and reduced to about 1 kilogram through the sampling process outlined above under *"Sampling,"* placed in a bottle which is then sealed, and brought to the laboratory by the representatives of both buyer and seller. In this way any possible controversy regarding sampling will be avoided and the transaction made fair to all concerned.

Conclusion.—The steady development of guano exploitation depends upon adequate knowledge of the various factors indicated. This is necessary to insure reasonable uniformity of the guano output and to avoid the admixture of foreign materials which would lower the grade of the guano. Another important factor is adequate financial returns for the guano output. Local fertilizer manufacturers can aid greatly in fostering the development of the guano industry by paying fair prices and allowing reasonable conditions with respect to the guano supplied. Coöperation between the people engaged in exploiting guano and the fertilizer manufacturers, to the end that a good grade of guano can be obtained at a fair price, will place the guano industry on a solid and profitable basis.

Table 1 gives the analyses of samples drawn from large shipments of guano from caves in Batangas, Bohol, Masbate, Mindoro, Iloilo, and other parts of the Philippine Islands.

TABLE 1.—*Analyses of Philippine guano samples.*

Laboratory No.	Water.	Nitrogen.	Phosphorous pentoxide.	Laboratory No.	Water.	Nitrogen.	Phosphorous pentoxide.
	P. ct.	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*
147675	------	1.05	17.04	150018	28.11	0.93	16.98
147730	------	1.14	19.14	150026	35.30	2.08	13.27
147739	------	1.05	10.12	150237	------	3.30	7.17
147881	------	0.74	17.81	150381	11.84	1.58	17.15
147881	------	0.72	17.45	150574	22.50	2.31	9.29
148252	26.23	1.13	17.45	150574	25.79	0.80	12.76
148252	20.92	0.64	15.25	150729	28.83	0.65	19.02
148333	------	0.65	14.86	150730	30.06	0.87	10.29
148333	------	0.60	13.93	150731	20.75	1.62	5.21
148377	27.93	3.79	15.35	150732	23.87	0.62	11.16
148685	24.00	4.51	16.00	150733	25.48	1.07	15.60
148686	------	0.56	5.61	150734	22.21	2.29	9.90
148686	------	0.42	10.54	150769	------	0.40	21.06
148707	------	0.88	16.59	150769	------	0.43	8.93
148734	23.67	1.36	8.53	150769	------	0.25	14.14
148795	23.42	1.15	8.66	150769	------	0.63	8.35
149298	20.45	2.11	6.36	150769	------	0.23	4.07
149298	20.35	3.29	8.16	150769	------	0.31	5.27
149298	18.50	3.28	4.67	150769	------	0.33	7.26
149780	25.56	1.43	11.34	150814	30.79	0.96	9.39

ROCK PHOSPHATE

In the various sections of the Islands rock phosphate is found, generally in caves formed in limestone. The deposits consist of excrement of birds and bats which inhabit the caves in vast numbers. The guano is generally mixed with limestone, breccia, and bowlders and layers of travertine or calcareous tufa which has been phosphitized through the leaching of overlying guano. The guano is generally pulverulent on the surface, but becomes compact at greater depth. There is considerable variation in the deposits of the different caves. Some are granular, porous, and friable, or white, pink, black, or yellow; others are dense, massive, and homogenous, or white or yellow. A superior grade of this material may contain from 20 to as high as 40 per cent of phosphorous pentoxide. The greater part of the phosphoric acid present in the rock is largely in unavailable form, and would require further study to convert it into a form readily

assimilable by plants. At present this material is utilized to a limited extent in the manufacture of local fertilizers.

This phosphate is quite different from that found in Tennessee and Florida; there the phosphate is largely in the form of tricalcium phosphate, whereas that found locally is largely in the form of iron and aluminium phosphate. So far no deposit of phosphate in the form of tricalcium phosphate has been found in the Philippines in commercial quantities.

Table 2 shows analyses of various layers of typical deposits of rock phosphate in Dumarao, Capiz Province.

TABLE 2.—*Analyses of thirty-two samples of Philippine rock phosphate.*

No.	Sample.	Thickness.	Phosphoric anhydride (P_2O_5).
		Meters.	*Per cent.*
1	Lanag cave:		
	Sample 1	0.50	18.68
2	Sample 2	0.50	18.14
3	Palasan cave, only sample	1.10	13.48
4	Diono's cave:		
	Hole A, sample 1	1.00	40.37
5	Hole A, sample 2	1.00	33.99
6	Hole A, sample 3	1.00	28.92
7	Hole A, sample 4	0.50	27.77
8	Hole B, sample 1	1.50	33.47
9	Hole B, sample 2	1.50	33.83
10	Hole B, sample 3	1.50	31.67
11	Hole C, only sample	2.00	28.90
12	Hole D, sample 1	1.20	22.24
13	Hole D, sample 2	1.80	34.14
14	Hole E, sample 1	1.80	29.24
15	Hole E, sample 2	1.20	34.74
16	Lapus cave:		
	Hole B, only sample	1.50	38.36
17	Hole C, only sample	1.50	35.97
18	Colvin's cave:		
	Hole B, sample 1	0.80	26.80
19	Hole B, sample 2	0.50	20.42
20	Hole B, sample 3	0.60	11.00
21	Hole C, sample 1	1.50	30.17
22	Hole C, sample 2	1.50	34.13
23	Hole C, sample 3	1.50	34.04
24	Hole D, sample 1	1.50	29.25
25	Hole D, sample 2	1.50	32.40
26	Hole D, sample 3	1.30	37.36
27	Modesta Mendoza's cave:		
	Hole A, sample 1	1.00	28.49
28	Hole A, sample 2	1.50	31.09
29	Hole B, one sample	1.00	28.93
30	Villanueva's cave 1:		
	Sample 1	2.00	2.83
31	Sample 2	1.00	2.37
32	Villanueva's cave 2, one sample	2.50	19.63

SALT

By TIMOTEO DAR JUAN [1]

Some nine or ten years ago, the Bureau of Science conducted an investigation into the salt industry with a view of ascertaining its true status and suggesting methods better adapted to conditions prevailing in the Philippines. The results of that investigation were published in 1915.[2] Since then many new salt crystallizing plants have been established and the annual production has proportionally increased. In 1924, the quantity of salt produced locally was 28,925 metric tons, valued at 542,147 pesos, and in 1925, 30,586 metric tons, worth 555,423 pesos. The production by provinces is as shown in Table 1.

TABLE 1.—*Philippine salt production in 1924 and 1925, by provinces.*

Province.	1924		1925	
	Metric tons.	Value.	Metric tons.	Value.
		Pesos.		*Pesos.*
Antique	75	2,900	61	2,438
Bataan	43	1,908	41	1,823
Batanes	3	428	4	495
Batangas	867	34,690	1,024	40,960
Bohol	41	1,012	41	1,012
Bulacan	653	12,387	747	13,810
Cagayan	16	635	18	720
Capiz	45	1,250	46	1,295
Cavite	14,000	165,000	14,350	167,000
Cebu	1,059	67,141	1,521	43,980
Ilocos Norte	123	5,593	169	8,942
Ilocos Sur	1,503	59,560	1,708	77,100
Iloilo	547	25,190	579	26,570
Union	270	14,812	270	14,812
Marinduque	1	70	1	70
Misamis	25	1,250	25	1,250
Mountain	2	200	2	200
NuevaVizcaya	37	4,686	31	4,680
Occidental Negros	8	560	10	700
Palawan	9	360	10	400
Pangasinan	590	13,528	942	18,908
Rizal	7,345	93,640	7,345	93,640
Romblon	22	1,900	22	1,900
Samar	1	22	2	58
Zambales	40	1,420	35	1,355
Zamboanga	1,600	32,000	1,000	32,000

[1] Chemist, Bureau of Science.

[2] Philip. Journ. Sci. § A 10 (1915) 375.

Notwithstanding the increased local production, our yearly imports of salt seem to indicate that the home product is not as yet sufficient to supply the demand for this commodity at a price low enough to compete with the imported product of the same grade and quality. In this connection, Table 2, showing the Philippine imports of salt for the last ten years, may prove of interest.

TABLE 2.—*Salt imports into the Philippine Islands from 1916 to 1925, inclusive.*

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	kg.	*Pesos.*		*kg.*	*Pesos.*
1916	2,473,156	50,323	1921	----------	13,258
1917	7,292,709	184,268	1922	130,153	15,341
1918	6,856,877	219,958	1923	5,258,991	131,436
1919	127,953	18,289	1924	7,559,089	206,175
1920	----------	24,260	1925	322,984	23,885

The principal source of our importations of coarse salt is China. Considering that the imported salt has to pay an import tax of 25 per cent ad valorem and that the local manufacturer must compete only with salt produced by the same methods as he himself employs, the local salt industry should find much encouragement and there should be a good margin of profit. Information obtained from owners of salt plants in the vicinity of Manila shows that the approximate cost of production of salt from a surface area of 10,000 square meters is as shown in Table 3.

It has been estimated that the amount of salt that can be produced in five months of operation, from December to April inclusive, is about 4,350 cavans, at a cost of about 0.37 peso per cavan. The weight of one cavan of salt is about 50 kilograms. It must be borne in mind, however, that the production varies from year to year, depending, of course, on the amount of interference by rainfall and the occurrence of cloudy days. As can be seen from Table 3, the various items that make up the cost of an article of commerce are exemplified in the salt industry of the Philippines. The raw material (sea water) has no value other than that incurred through the unskilled labor expended in reducing it to salt, and the cost of the tide land involved. Moreover, the introduction of the water-evaporating reservoirs is a labor-saving item.

TABLE 3.—*Showing approximate cost of salt production in the Philippine Islands.*

	Pesos.
10,000 square meters of salt land	300
Excavation, leveling, and construction of dikes	2,000
Materials for crystallizing vats, and labor	1,100
Warehouse	300
Miscellaneous expenses	200
Working capital	500
Total	4,400
Cost of operation:	
Four laborers, at 35 pesos per month each, for five months	700
One foreman, at 60 pesos per month, for five months	300
Maintenance	200
Interest at 8 per cent per annum	352
Taxes on the salt plant and the salt produced	68
Total	1,620

Taking into account that common salt is an important raw material in the manufacture of chemicals such as soda ash and caustic soda, which the country needs so that her natural resources can be converted into useful products, the importance of increasing our salt production to encourage the manufacture of these chemicals cannot be overemphasized.

SAND, GRAVEL, AND BROKEN STONE

By RAFAEL H. AGUILAR [1]

No systematic study has yet been made of the sand, gravel, and stone resources of the Philippines. However, in connection with the rapid development of concrete construction during the last seven years, natural deposits of concrete materials have been located in various provinces by engineers and contractors engaged in this line of work. Sufficient data have been gathered in this manner to furnish some idea of the available material, its quality, accessibility, estimated quantity, and approximate cost per unit volume.

Deposits of sand, gravel, and stone are found everywhere. Sands consisting mainly of medium and fine particles and weathered gravel of low concrete value are the most abundant and most widely distributed. Estimates made of the various specimens submitted for test in the Bureau of Science lead to the conclusion that the greater proportion of the sand and gravel materials is andesitic and basaltic, the rest consisting of coralline limestone and volcanic products. Materials of good quality are found in large quantities in Albay, Bulacan, Cebu, Laguna, and Rizal Provinces, and in Mindanao Island. Those from Batangas and Cavite are of poor quality. In the other provinces, the materials possess widely variable physical properties.

Sand, gravel, and stone of good quality have been reported to exist in quantities which might justify their exploitation on a commercial basis in several localities. These are discussed in the following paragraphs under the provinces, arranged in alphabetical order, excepting those in Mindanao, which are placed under Mindanao, and that island is, in the present discussion, regarded as a province.

SAND

Albay.—Yawa River (Daraga) Creek, Legaspi-Agus Road, Kilometers 32 and 36, and Polangui River (Polangui).

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[1] Chemist, Bureau of Science.

Antique.—Ipil River (Ipil), Magranca Beach, Sibalom River and Tinpuluan River (Sibalom), Carauagan River (Valderrama).

Bataan.—Talisay River (Balanga), Orani River and Patolo River (Orani), Orion River and San Vicente River (Orion).

Batangas.—Batangas beach (Batangas), Bauan River (Bauan), Lumbang River (Calaca), Pangasinan River (Rosario), Tanawan River (Santo Tomas), Talisay Beach (Talisay, Lake Taal).

Benguet.—Limestone quarry (Baguio).

Bohol.—Masing River (Colonia), seashore at Umpas Sunculan (Dauis), seashore at Tanguhay (Dimiao), seashore at Duero (Duero), seashore at Guindulman (Guindulman), seashore at Jetafe (Jetafe), seashore at Kilometer 25 (Loay), seashore at Punta Cruz (Maribohoc), Tagbilaran beach at mouths of creeks (Tagbilaran), mouth of Panangatan River (Valencia).

Bulacan.—Angat River (Angat), Bocaue River (Bocaue), Angat River Bustos), Bagbag River (Calumpit), Pulilan River (at Tibag, Pulilan), Paombong River (Malolos), Santa Maria River (Santa Maria), San Miguel River (San Miguel).

Cagayan.—Casabalangan (Aparri).

Camarines Norte.—Tungos Creek (Paracale).

Capiz.—Panay River (Dao), bar at Lawain-Capiz River (Ioisan).

Cavite.—Noveleta River (Noveleta), river bed opposite Ternate.

Cebu.—Argao River and Argao beach (Argao), Asturias beach (Asturias), Mananga River (Carcar), Guadalupe River (Cebu), Mananga River (Cebu), Town beach (Daan Bantayan), Liloan beach (Liloan), Mandawe beach (Mandawe), Butuanon River (Opon), Pinamugahan beach (Pinamugahan), Poro Beach (Poro), San Remigio River (San Remigio), beach at mouth of creek (Santander).

Ilocos Norte.—Laoag River (at Bank, Laoag), river at dam site (Vintar).

Ilocos Sur.—Santa Cruz River (Candon), Govantes River (Vigan).

Iloilo.—Aganao River and Oton beach (San Miguel), Santa Barbara River (Santa Barbara).

Laguna.—Bay River (Bay), Majayjay River (Majayjay), Pagsanjan River (Pagsanjan), Mayton River (Rizal), Santa Cruz River (Santa Cruz), Bañadero River and Lucena beach (San Pablo).

Leyte.—Dapdap River (Alang-Alang), Carigara River (Carigara), Guinarona River (Dagami), Anilao River (Ormoc), Malirong River (Palo), Calogcog River (Pastrana), Tigbao River (Tacloban).

Marinduque.—Boac seashore (Boac), Gasan beach (Gasan).

Masbate.—Baleno seashore (Masbate), Asid River (Milagros).

Mindanao:

Misamis.—Cagayan beach and Cagayan River, Iponan River, and mouth of Cugman River (Cagayan).

Cotabato.—Cotabato River, Rio Grande, and Linuac beach.

Davao.—Davao River, 2.5 kilometers from Davao.

Surigao.—Surigao beach.

Zamboanga.—Baliwasan beach and Zamboanga beach.

Nueva Ecija.—Caranglan River (Caranglan), Rio Grande (Cabanatuan).

Occidental Negros.—Lupit River (Bacolod), Alejandria River (La Carlota), Bungahin River (La Castellana), Marangandang River (Maao), Matabang River (Talisay).

Oriental Negros.—Bais River (Bais), Ocoy River (Dumaguete).
Palawan.—Beach near wharf (Coron).
Pampanga.—Abacan River (Angeles), Valdez River (Floridablanca), Quitangil River (Magalang), Barrios San Agustin and Santo Rosario (Mexico).
Pangasinan.—Aguilar River (Aguilar), Barrio San Juan (Alcala), Balicanging River (Anda), Villasis River (Balungao), Tambacan River (Burgos), Calasiao, Malabago River, Mariquita River, Santa Barbara River, and Tarlac River (Calasiao), Labrador River (Lingayen), Malasiqui River (Malasiqui), Ano Nilintap River (San Carlos), Mapandan River and San Jacinto River (San Jacinto), Agno River (Tayug).
Rizal.—Mariquina River (Mariquina), Pasig River (McKinley), Pasig, River (Pasig).
Romblon.—Romblon beach.
Samar.—Bato River, Canabong beach, Soribas beach, and Sunco beach near Sanbang (Borongan), Calbayog beach and Tandaranao beach (Calbayog), seashore (at Catarman) near water reservoir at Catbalogan, Llorente beach (Llorente).
Sorsogon.—San Ramon River (Bulan), Yawa River (Castilla), Donsol River (Donsol), Ariman River and Sagurong River (Gubat), Talinga River (Juban), Lantic River and Sorsogon River (Sorsogon).
Tarlac.—Camiling River (Camiling), Santiago River (Capas), Cutcut River and O'Donnell River (San Miguel), Tarlac River (Tarlac).
Tayabas.—Cuyapo River (Candelaria), Agos River (Infanta), Siain beach (Lopez), Dumacaa River (Lucena), Sariaya-Munting River (Sariaya), Siain beach (Siain), Alitao River (Tayabas), Tiaong River (Tiaong), Kalylayan River (Unisan).
Zambales.—Anunang River, mouth of Cauayan River, and Cauayan-Kiling River (Cabangan), Bayto River (Santa Cruz), Santo Tomas River (San Marcelino).

GRAVEL AND STONE

Albay.—Cabraran River (Camalig), Yawa River (Daraga), Quinali River (Oas), Polangui River (Polangui).
Bataan.—Talisay River (Balanga), Sisiman quarry (Sisiman).
Benguet.—Engineers' hill and city quarry (Baguio).
Bohol.—Open field (Dauis), Brook, barrio Salog (Jetafe), beach, Kilometer 25 (Loay), Punta Cruz beach, Kilometers 14–22 Maribohoc.
Bulacan.—Angat River (Angat, Bustos, Quingua), Pulilan River (Pulilan), San Miguel River (San Miguel).
Capiz.—Capiz–Paintan, Road quarry, Kilometer 9.
Cavite.—Rio Grande River (Kawit).
Cebu.—Field bowlders (Carcar), Buhisan creek (Cebu), Rock quarry (Danao), Santander beach (Santander), Mananga River (Talisay), Tajao River (Toledo).
Ilocos Norte.—Laoag River (Laoag).
Iloilo.—Santa Barbara River and Tigum River (Santa Barbara).

Laguna.—Majayjay rock quarry and Olla River stone (Majayjay), Pagsanjan River (Pansanjan), Paac River (Rizal), Santa Cruz River (Santa Cruz).
Leyte.—Baluguhay River (Barugo), Anilao River (Ormoc).
Masbate.—Togbo River (Masbate).
Mindanao:
Cotabato.—Limapatoy River and Rio Grande.
Davao.—Davao River (Davao).
Zamboanga.—Baliwasan beach.
Nueva Ecija.—Rio Grande (Cabanatuan), Caranglan River (Caranglan).
Occidental Negros.—Lupit River (Bacolod), Talaba-an River (Cadiz), Bungahin River (La Castellana), Bago River (Pulupandan), Matabang River (Talisay).
Oriental Negros.—Amblan River (Amblan), Bais River (Bais), Tanhay (Tanhay).
Palawan.—Coron beach (Coron).
Pampanga.—Abacan River (Angeles).
Rizal.—Talim Island quarry (Binangonan), Pasig River (McKinley), San Juan River (San Juan), Mariquina River (Mariquina).
Samar.—Sitio Malo Palo (Calbayog), Llorente beach and Llorente River (Llorente), Kumadkad River (Castilla), Donsol River (Donsol).
Tarlac.—O'Donnell River and Cutcut River (San Miguel).
Tayabas.—Cuyapo River (Candelaria), Dumacaa River (Lucena), Alitao River (Tayabas), Gugulman River (Tiaong).
Zambales.—Santo Tomas River (San Marcelino).

Deposits have been reported in many other localities, but the materials have not been found to possess the necessary strength and durability for use in road or concrete work. Some fine sand of low concrete value, having an effective size as low as 0.14 millimeter, might be used satisfactorily on filter beds.

GENERAL PHYSICAL CHARACTERISTICS OF THE MATERIALS

The greater number of Philippine sands is characterized by the predominance of fine round particles which make them unsuitable for concrete construction. In many deposits, the proportion of these fine particles is so overwhelmingly large that separation from the coarser grains is commercially prohibitive. Along the course of some rivers, however, deposits of coarse and fine sands are available. Such deposits are found in Sibalom River, Antique Province, and Pasig River, Rizal Province. Sand and gravel possessing varying strength as concrete aggregates have also been located at different sections of some rivers. Bocaue River, Bulacan Province, Timpuluan River, Antique Province, and Pasig River, Rizal Province, furnish some exam-

ples. These occurrences are due no doubt to the influence of the tributaries of the rivers, their waters carrying disintegrated materials from rocks of varying mineralogic characters.

Coincident with the great variation observed in the granulometric composition and concrete value of the sand, gravel, and stone from the various provinces are the wide variations in the specific gravity, uniformity coefficient, and the percentage of voids of the specimens. The general variation in the specific gravity of sands is from 2.3 to 2.9, the general average being 2.64; and for gravel from 2.1 to 2.73, with a general average of 2.52. In the computation of these figures, the abnormally low specific gravity of various specimens from Cavite and Batangas have not been included. The variation in the uniformity coefficient of sands is from 1 to 6.3, the predominating figures being 2 to 3.5. The variation in the percentage of voids for sand and gravel is from 22 to 52, the predominating figures varying from 30 to 45.

METHODS OF PRODUCTION AND COMMERCIAL EXPLOITATION

Hand quarrying is the ordinary method of handling sand and gravel in the provinces. They are either loaded by shovels directly into bancas or cascos, or placed in bamboo baskets, to drain out the water, before loading. Fluvial distribution is very common. Sometimes they are hauled in wheelbarrows or carts drawn by carabaos to railroad stations at which places they are loaded by hand into the open cars. Distribution by rail is usually more expensive.

The sand and gravel deposits are almost always public property, and no charges are made for the materials. The production, however, is subject to taxation at the rate of 4 centavos per cubic meter. The cost of handling the materials depends upon the local facilities and the available methods of transportation. The average price paid for sand is between 1.50 and 2.50 pesos per cubic meter, and the average price paid for gravel is generally higher, owing to the relative scarcity of the material. In some special cases, however, prices as high as 8 and 15 pesos have been paid for every cubic meter of sand and gravel, respectively. Cases like these occurred when the importance of the work required the use of good-grade material and, this not being available in the neighboring localities, it had to be transported from considerable distances. In the construction of the Jolo wharf sand was transported from Baliwasan beach and Tunaga River, Zamboanga, to Jolo, at a cost of 8

and 10 pesos per cubic meter, and the price paid for gravel was at the rate of 15 pesos per cubic meter. Of course, these high prices should be attributed directly, to a great extent, to the lack of convenient methods and facilities for handling the materials.

In Manila there is a constant demand for concrete materials, the methods of quarrying and handling employed are more modern, and the business apparently is established on a commercial basis. Sand and gravel are being supplied from the beds of Pasig, Mariquina, and San Juan Rivers, and the crushed stone is taken from a basaltic quarry at Talim Island. All these places are located in Rizal Province, adjoining Manila. Occasionally gravel from the bed of Angat River at Quingua, Bulacan, is transported to Manila by rail. This gravel generally makes a better concrete material than do any of the gravels in Rizal Province, and it is especially adapted for certain construction requiring greater strength and durability.

The busiest period for building and road construction and repair in Manila starts from the month of October and lasts until June or July. During this interval of time usually four sand gravel dredges are constantly working in Pasig River and its tributaries to supply the demand for this material. The production varies from 2 to 5 cubic meters per hour during a working day of about ten hours. The material, after screening, is loaded into barges, and these are hauled in series of three or four by small tugs to Manila. Through the different canals or estuaries, the barges are taken as near as possible to the sites of the jobs, at which points the unloading is usually done by hand. Indications are that the deposits of sand and gravel in the bed of Pasig River, which formerly were considered to possess unlimited quantities of the materials, are now becoming exhausted. Reliable information, however, points to the discovery of another extensive deposit of unknown depth, farther up and near the banks of Pasig River on land already covered with earth and vegetation. The exploitation of this deposit will eventually take place when the dredges working on the present supply can no longer operate on a commercial basis. The prices paid for sand and gravel in Manila, delivered at the sites of the jobs, is 2 and 3 pesos per cubic meter, respectively.

Quarrying by hand is also practiced to a certain extent farther up the Mariquina and San Juan Rivers, Rizal, in shallow places. The business is in the hands of small capitalists, and

the materials are sold in small quantities, but usually at higher prices, for less-important construction.

The quarrying of stone in Talim Island is done by dynamite blasting. The large pieces are crushed by machinery into convenient sizes, depending upon the purpose for which they are to be used. For concrete making the largest size is about 3 inches; for road building, larger sizes are supplied. The production is in the neighborhood of 400 cubic meters per working day of nine hours. The price paid per cubic meter, delivered at the sites of the jobs, is between 3.50 and 5 pesos. The material is transported from Talim Island to Manila in barges, in much the same manner as are the sand and gravel dredged from Pasig River.

FUTURE OUTLOOK

If the present progressive development of concrete construction work in the provinces, and more especially in Manila, will continue, it is urged that systematic methods of exploitation of the sand, gravel, and stone resources of the country be devised. The most important step to be considered is an accurate survey of the quantity, extent, and quality of the deposits and the facilities for exploitation. The present condition of the dredging works of the Pasig River deposits points to the fact that no conscientious study was made before dredging operations started. There have been cases in which the dredges worked hour after hour raising out of the water large quantities of mud and only comparatively small quantities of sand and gravel. A change of location of the dredges did not always produce the desired results. It is apparent that, if successful commercial exploitation of these natural resources is to be expected, an accurate, conscientious survey of the deposits should first be made.

STONE, BUILDING AND ORNAMENTAL

By LEOPOLDO A. FAUSTINO

TABLE 1.—*Stone production in 1924 and 1925, by provinces.*

Province.	1924		1925	
	Cubic meters.	Value.	Cubic meters.	Value.
		Pesos.		*Pesos.*
Batangas	715	890	738	1,026
Bulacan	9,296	14,025	8,374	11,992
Cavite	11	108	11	108
Laguna	7	72	5	50
Mountain			169	3,301
Rizal	2,926	19,588	3,826	26,631
Romblon [a]	0.6	2,895	0.6	2,895
Total [b]	16,894	43,068	17,062	51,493

[a] Marble. [b] Includes estimate of unreported production from other provinces.

Stones for building and ornamental purposes are distributed throughout the Archipelago. The principal building stones are andesites and basalts and other volcanic rocks, a water-laid volcanic tuff commonly called "dhobe" or "adobe" stone, and limestones. Marble is the chief ornamental stone.

Several quarries of andesite and basalt have been opened up. To supply stone for building the breakwater and for the harbor improvements of the City of Manila a large commercial quarry was opened at Sisiman, near Mariveles in Bataan Province. The stone obtained is andesite, and is better known as Sisiman andesite. This stone has been known since Spanish times and was used as a building stone and for paving blocks in the City of Manila. The columns of the Monte de Piedad building in Plaza Goiti, in the heart of the City of Manila, are of Sisiman andesite. The stone has a soft, gray appearance when weathered. The one serious objection to the use of Sisiman andesite is its tendency to scale.

Andesite, basalt, and other volcanic rocks are also cut and used in the provinces in the construction of foundations, the lower stories of buildings, and churches. They are used prin-

cipally in places where the transportation cost prohibits the importation of cement.

The principal building stone used in Manila and in the nearby provinces for some years is the water-laid volcanic tuff, the so-called "dhobe" or "adobe" stone. Several quarries have been opened up in the tuff area, but the deposits at Guadalupe, Rizal, and Meycauayan, Bulacan, are the best known and have been given trade names. The stone is soft and easily quarried, but hardens somewhat upon exposure. The tuff has low compression and tensile strength, and when used in the construction of large buildings very thick walls are generally required.

In several towns along the coast, notably in Cebu, coralline limestones have been quarried and used as building stones in the construction of houses and churches. Many churches in Cebu are built of coralline limestone, and Magellan's monument on Mactan Island is made of this limestone.

The best-known ornamental stone is the Romblon marble, which is quarried on Romblon Island. The Romblon marble is a gray-blue mottled stone, capable of taking a high polish. The stone has been used principally for monuments and tombstones, and in the form of chips as ornaments in concrete facings. The serious objection to the use of Romblon marble for monuments and tombstones is the alleged difficulty of obtaining blocks of suitable size free from joints.

The Philippine Islands has been importing building and ornamental stones from neighboring countries and from Europe and America. In certain parts of old Manila slabs of granite imported from Hongkong used in sidewalk construction can still be seen. The greatest importation of marble comes from Italy. In 1924 the importation of marble and stone amounted to 97,727 pesos and in 1925 to 77,069 pesos.

SULPHUR

By LEOPOLDO A. FAUSTINO

Sulphur occurs as a sublimate in the crevices around volcanoes (called solfataras), and also as an impregnation in tuffs. The better-known deposits are around volcanic vents, at the orifices of hot springs that carry hydrogen sulphide, and extinct volcanic and fumarolic centers. On account of the wide distribution of active, dormant, and extinct volcanoes in the Philippines, sulphur deposits are known from Camiguin Island, north of Luzon, to Mount Apo in southern Mindanao. The better-known localities, however, are the following:

Camiguin Island, Cagayan Province.
Biliran Island and Burauen, Leyte Province.
Mount Silay, Occidental Negros Province.
Mount Apo, Davao Province.
Camiguin Island, Misamis Province.
Pocdol Mountains, Sorsogon Province.

There is no production of sulphur at the present time. There was a little production during the World War, when 72 metric tons, valued at 11,140 pesos, were produced in 1918 and 12 metric tons, valued at 1,680 pesos, were produced in 1919. The small production came from Mount Silay, in Occidental Negros Province. The sulphur was simply gathered by hand, put in sacks, and carried on the backs of men to a collecting place, from where it was afterward transported to Iloilo. Since 1919 all operations on the sulphur deposits ceased, and the outlook for sulphur mining is not very encouraging.

The sulphur deposits in Camiguin Island north of Luzon were visited by Ferguson, of the division of mines, in 1910, and in 1918 they were investigated by local capitalists. It has been claimed that the deposits are worthy of exploitation and that about 4,100 metric tons of commercial sulphur are in sight. Analysis of an average sample of this sulphur, made by Reibling of the Bureau of Science, gave the following results: Sulphur, 81.6 per cent; arsenic, trace; selenium, none.

Lack of sufficient capital, however, properly to finance the work prevented the installation of machinery and the exploita-

tion of the deposit. The deposit in Burauen, Leyte Province, was estimated to contain about 3,000 metric tons, and that in Biliran Island in the same province about 400 tons. The available sulphur on Mount Silay, Occidental Negros, was estimated as not exceeding 300 tons. On Mount Apo, at about 1,400 meters elevation, small mounds of sulphur are estimated to contain between 500 and 1,000 metric tons. The deposits at Camiguin Island north of Mindanao, and on Pocdol Mountains, Sorsogon Province, are small. These estimates of available sulphur were made after a superficial examination; on account of the nature of the deposits, which are irregular both in extent and in depth, it is impossible to make a close estimate.

The important uses of sulphur in the Philippines have been as a fumigating substance and as a protector against plant diseases. However, its use in the drying of copra has been protested against by United States refiners of coconut oil, for the reason that mere traces of sulphur poison the active action of the catalytic agents.

ADMINISTRATION AND DISPOSAL OF MINERAL LANDS IN THE PHILIPPINES

By VICTORIANO ELICAÑO

Mining laws and regulations.—At the present time both the freehold and the leasehold systems prevail in the Philippines. The following are the laws and regulations governing the system of mineral administration and disposal in the Philippines.

1. Minerals other than coal or petroleum are disposed of in accordance with Sections 20 to 62, inclusive, of Act of Congress of July 1, 1902, with the amendments by Act of Congress of February 6, 1905; Act of Philippine Commission No. 624 as amended by Acts of Philippine Commission Nos. 777, 859, 1134, and 1399.

2. The disposition of coal lands is provided for by the Coal Land Act No. 2719 of the Philippine Legislature approved May 14, 1917, together with regulations promulgated August 15, 1917.

3. Petroleum lands are governed by Act 2932 of the Philippine Legislature as amended by Section 1 of Act No. 3054 approved by the President of the United States on August 31, 1920, and made effective on September 2, 1920, by proclamation No. 34, series 1920, together with regulations originally approved by the Council of State October 13, 1920.

4. Under the Jones Law (Act of Congress of August 29, 1916) Philippine Legislation referring to land of the public domain, timber, and mining is subject to veto by the President of the United States. In case he fails to act within six months after receipt of a bill, it automatically becomes a law.

DISPOSITION OF MINERAL LANDS OTHER THAN COAL OR PETROLEUM

All valuable mineral deposits, except of coal or petroleum, in public lands are open to exploration, occupation, and purchase, and the lands in which they are found are open to occupation and purchase by citizens of the United States or of the Philippine Islands. Claims are located either as lode claims or as placer claims. There are no extra-lateral rights and all operations are confined by all side lines extended vertically downward.

Lode-claims.—Lode claims include lands containing veins or lodes of quartz or other rock in place bearing valuable deposits. These claims are square, of 300 meters on a side, and a locator, whether an individual or an association of persons, is limited to one claim on each vein or lode.

Placer claims.—Placer claim is understood to mean a claim of land more valuable for placer mining, stone quarrying, or for the securing of earth for use in tile, brick, pottery, paint,

or other manufacture, or of guano or other mineral products, than for other purposes. Placer claims are generally rectangular, and their extent shall not exceed 8 hectares for each individual claimant, and no claim shall exceed 64 hectares for any association of persons, irrespective of the number of persons composing such association.

Assessment work and acquisition of patent.—Before a patent can be obtained not less than 200 pesos worth of labor shall be performed or improvements made during each year on each claim, whether lode or placer. Upon certification that at least 1,000 pesos worth of labor has been done or improvements made upon a claim, a patent or title thereto may be applied for by the locators or grantors. An affidavit of assessment work must be filed within sixty days after expiration of the period fixed by law for the annual performance of the labor, which shall commence on the first day of January succeeding the date of location of the claim.

Mill site.—A mill-site claim may be located in a nonmineral land not contiguous to a lode claim, but the area of such claim shall not exceed 2 hectares. Patent for such mill site may also be acquired in the same manner as in lode claims.

Saline lands.—Saline lands, incapable of being purchased under any of the laws relative to the public domain, are sold to the highest bidder for cash at a price of not less than 6 pesos per hectare.

Taxes and fees.—All mineral products, except coal and petroleum, pay a tax of 1.5 per cent on the gross output. Mineral products, except coal and cement, exported to other countries, pay a wharfage charge of 2 pesos per metric ton.

A fee of 2 pesos is collected on the registration of each of the following instruments:

(*a*) Declaration of location.
(*b*) Affidavit accompanying declaration of location.
(*c*) Affidavit of annual assessment work.
(*d*) Notice of intention to obtain a mining claim.
(*e*) Any instrument executed by claimant to a third party alienating, mortgaging, leasing, or otherwise affecting the possession of his claim or his right or title thereto or interest therein.

Miscellaneous provisions.—Discovery is necessary to locate a claim.

All locations shall be recorded with the provincial secretary or the mining recorder designated for the district, within thirty days after the location of the claim.

Persons interested in one mining company are prohibited from having financial interests in any other, although no penalties are provided for disregard of this provision.

Miners' license for cutting timber must be secured from the Bureau of Forestry. Timber cut within a mining claim will cost the owner nothing; if outside the mining claim and to be used for mine development, one-half the usual Government charge.

All water rights in the Philippines are subject to the Spanish Law of Waters of August 3, 1866, and are administered by the Secretary of Commerce and Communications through the Director of Public Works, according to the provisions of Act of the Philippine Legislature 2152, as amended by Act 2652. Priority of appropriation of all public waters is as follows: Domestic, agriculture, industrial, ponds and fisheries, mining, milling connected with mining. The appropriator of water for power purposes for large development must pay the Government an annual rental of 50 centavos per horse power for the first ten years; after that, the rate is to be determined by the Secretary of Commerce and Communications.

Corporations.—All corporations must comply with the provisions of the Corporation Law, Act 1459, as amended. Section 6 of this law reads—

> Five or more persons not exceeding 15, the majority of whom are residents of the Philippine Islands, may form a private corporation for lawful purposes by filing with the Bureau of Commerce and Industry articles of incorporation laws duly executed, ...

Section 68 reads—

> No foreign corporation or corporations formed, organized or existing under any laws other than those of the Philippine Islands, shall be permitted to transact business in the Philippine Islands until after they shall have obtained a license for that purpose from the Director of Commerce and Industry either upon the order of the Secretary of Finance (in case of banks) or upon the order of the Secretary of Commerce and Communications in the case of all other foreign corporations.

Fees, graduated according to capitalization, are charged for the filing of articles of incorporation; and a foreign corporation must pay similar fees in order to secure license to do business in the Philippine Islands.

LAWS RELATING TO COAL LANDS

Citizens of the United States or of the Philippine Islands, or corporations the majority of whose stockholders are citizens

of the United States or of the Philippine Islands, may take out leases for periods of not more than fifty years on coal lands in the public domain, in blocks of not less than 400 nor more than 1,200 hectares each. No lessee may acquire more than 1,200 hectares.

Leases are usually granted to the highest bidder; but, when the highest bid has been ascertained, a lease is issued to the one having preference in time of application. No bid is received for a royalty of less than 10 centavos per ton of 1,016 kilograms, nor without a statement of the work that the bidder will guarantee to perform annually. The rental is 2.50 pesos per hectare for the first year and 5 pesos per hectare every year thereafter during the continuance of the lease. The rental for any year shall be credited against the royalties as they accrue for that year. In addition to the above royalty the production is subject to a specific tax of not less than 50 centavos per ton.

No person, association, or corporation is permitted to take or hold any interest as a stockholder or otherwise in more than one lease.

To provide for the supply of strictly local and domestic need for fuel, a limited license or permit may be granted for a period of not exceeding ten years, to prospect for mines and dispose of coal on specified tracts not to exceed 4 hectares, under the following restrictions: Not more than one prospecting ground shall be issued to any single applicant. Not less than 200 pesos worth of work shall be done annually on the development of the ground. A payment of an Internal Revenue tax of 50 centavos per ton of 1,016 kilograms is required.

Subleases will be allowed, only in special cases, by the Secretary of the Department of Agriculture and Natural Resources.

On lands of private ownership, there is an annual tax of 2,000 pesos on each block of 400 hectares or fraction thereof, and a tax of 4 centavos on each ton of 1,016 kilograms, which taxes are in lieu of all other taxes.

LAWS RELATING TO PETROLEUM LANDS

All public and privately owned lands containing petroleum or other mineral oils and gas may be applied for under lease for geological exploration or for development or drilling purposes by citizens of the Philippine Islands or of the United States, or by corporations organized and constituted under the laws of the Philippine Islands or of the United States or of any state or territory thereof and authorized to do business

in the Philippine Islands. Citizens of another country are granted the same privilege, provided the laws, customs, or regulations of their country grant similar or like privileges to citizens or corporations of the Philippine Islands or of the United States.

Area and duration of leases.—All leases, whether for geological exploration or for drilling purposes, cover blocks of 400 hectares for an individual, and of 1,200 hectares for an association or corporation. At the discretion of the Secretary of Agriculture and Natural Resources more than one lease may be granted, but the maximum area allowed to individuals is 6,000 hectares, and to corporations or associations, 18,000 hectares.

The term of a drilling lease is five years and successive renewals are permitted, as long as *bona fide* operations continue, up to fifty years. After fifty years a new application may be filed in accordance with the rules and regulations.

In the case of geological exploration the term is for only one year, but the lease may be renewed for another year.

Bonds.—All lease applications must be accompanied by certified bonds in favor of the Government, the amount of which, in case of drilling leases, is 1,000 pesos plus 500 pesos for each 100 hectares or fraction thereof of the area applied for; in the case of geological exploration leases the amount is 2,000 pesos. A cash deposit, calculated on the basis of 5 centavos per hectare leased, is also required in geological exploration leases.

Rentals and royalties.—The lessee must agree to commence boring a well upon the premises leased to him not later than eighteen months from the date of the lease, provided that, when the leasehold is beyond 25 kilometers from the coast, the time limit for the commencement of boring operations shall be extended to three years. Upon failure of the lessee to commence boring a well, as provided, he shall pay rentals to the Government, during the period of the lease, until boring operations are commenced. The following rentals are charged:

For leaseholds within 25 kilometers from the coast by the most direct feasible route—
- First year, free.
- Second year:
  - First semester, 1 peso per hectare.
  - Second semester, 4 pesos per hectare.
  - Third year, fourth year, and fifth year, each, 5 pesos per hectare.

For leaseholds beyond 25 kilometers from the coast by the most direct feasible route—
First year, free.
Second year and third year, each, 1 peso per hectare.
Fourth year and fifth year, each, 5 pesos per hectare.

In the event of the successful development and operation of drilling leases, the lessee shall deliver as royalty to the Government, at the well, part of the oil produced and saved, at the following rates.

For leaseholds within 25 kilometers from the coast:
With a monthly production averaging—
Fifty barrels per well per day, 12.5 per cent.
Less than fifty barrels per well per day, 10 per cent.
For leaseholds beyond 25 kilometers from the coast:
With a monthly production averaging—
Fifty barrels per well per day, 10 per cent.
Less than fifty barrels per well per day, 8 per cent.

The rates of royalty shall be based upon the amount of oil produced and saved, excepting such oil as is used by the lessee in his operation on the premises, which shall be free from royalty.

The distances referred to are measured from the nearest producing well within the leasehold to the coast by the most direct feasible route.

The barrel used as a unit of measurement is the standard of 42 United States gallons, equivalent to 158.988 liters.

In the case of production of oil in privately owned land, 40 per cent of the royalty goes to the land owner.

In geological exploration leases, the lessee shall, within six months from the day of the execution of the lease, begin geological exploration within the area granted, and upon his failure to do so his bond, together with the deposit required, will be forfeited to the Government.

No operation or exploration may be carried on in privately owned land without the consent of the owner.

PROPOSED AMENDMENTS TO EXISTING LEGISLATION

By VICTORIANO ELICAÑO

The Philippine Chamber of Mines and Oil, in representation of the mining men of the Archipelago, has been responsible for the drafting of four bills, amendatory and remedial in nature, to further the development of the mineral resources of the Philippine Islands. These bills have been recommended by His Excellency, the Governor-General, to the Legislature, for favorable consideration. The amendments and relief requested are indicated in the following paragraphs.

1. An act amending the mining laws so as to permit locators of mining claims to hold in their own name ten contiguous mineral claims and also to permit the annual assessment work corresponding to this group of contiguous claims, held in common, to be concentrated on one or more claims of the group.

2. An act amending the corporation laws so as to permit members of a corporation engaged in mining to become also members of another mining organization.

3. An act amending the administrative code so as to eliminate the direct taxes on the products of mines.

4. An act amending the Philippine Tariff Act of 1909 so as to exempt certain articles from wharfage charge and to place on the free list certain imported articles used in mining.

These amendments have been fully discussed, by both mining men and Government officials directly concerned or affected by the proposed legislation, and have been exhaustively discussed in the Council of State, before final recommendation of the Governor-General to the Legislature.

The above proposed amendments, however, have not been viewed with favor by the Legislature, and the interest of the mining industry will perhaps be better served by the adoption of the leasehold system, to apply to all minerals.

In the matter of mineral taxation, it is deemed advisable to make the collection according to a sliding scale, and it should be based on the net profit rather than on the gross output.

With special reference to coal lands, it is believed that leases may be granted for blocks not exceeding 100 hectares.

Oversized Foldout


RELIEF AND HYDROGRAPHIC MAP
OF THE
PHILIPPINE ISLANDS
AND
NEIGHBORING SEAS
SCALE
Lines of equal depth, isobaths, are as follows:
100 meters, 500 meters, 1000 meters, 2000 meters etc.
Area between 100 meters and shore-line, white;
shaded areas mark by their increased intensity
increased depth.
Elevations in meters.
SULU SEA
CELEBES SEA
BABUYAN ISLANDS
BATAN ISLANDS
Balintang Channel

PLATE 2.

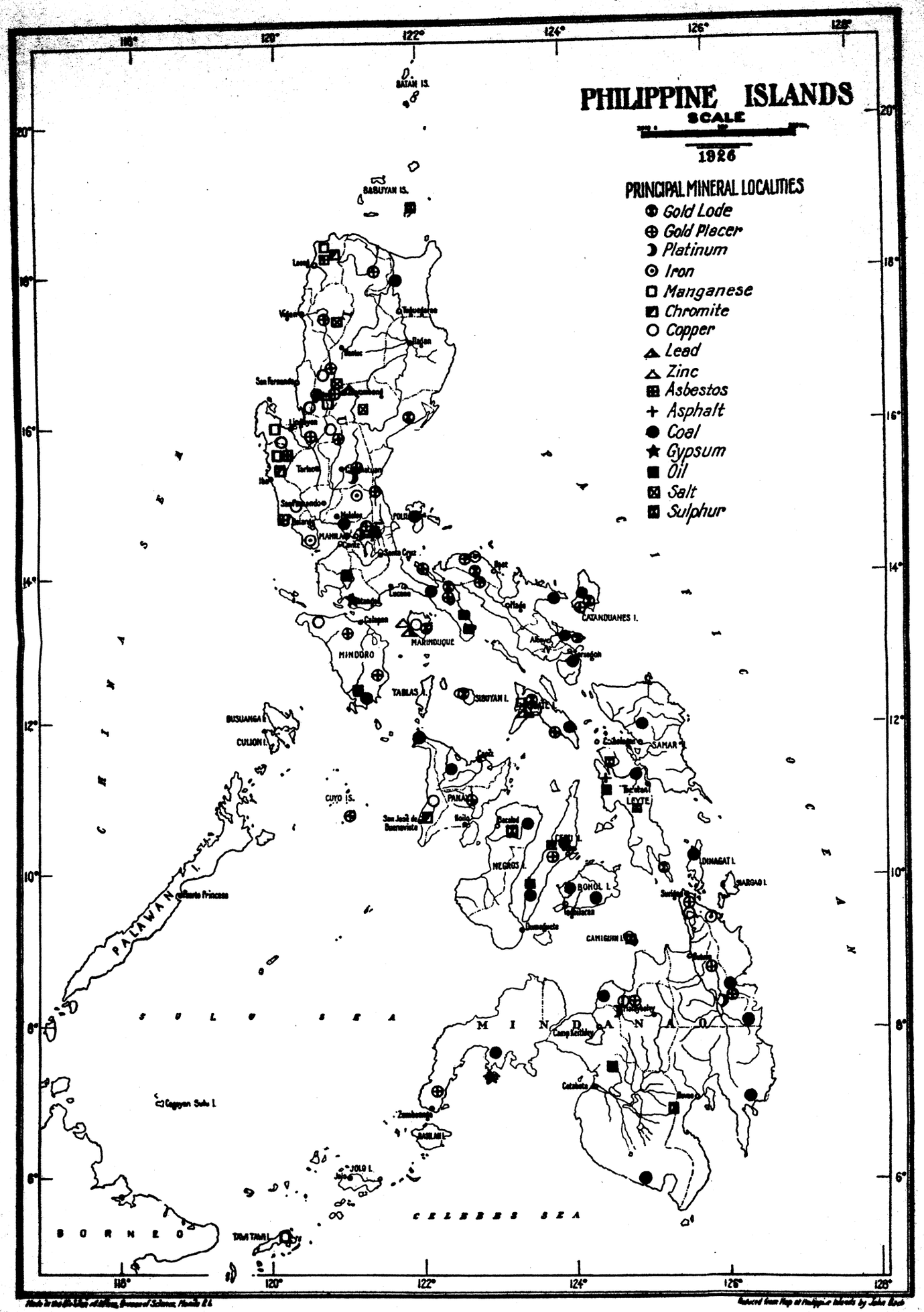
PHILIPPINE ISLANDS
SCALE
1926
PRINCIPAL MINERAL LOCALITIES
Gold Lode
Gold Placer
Platinum
Iron
Manganese
Chromite
Copper
Lead
Zinc
Asbestos
Asphalt
Coal
Gypsum
Oil
Salt
Sulphur
BABUYAN IS.
MINDORO
MARINDUQUE
CATANDUANES I.
TABLAS I.
SIBUYAN I.
BUSUANGA I.
CULION I.
CUYO IS.
PALAWAN
SAMAR
LEYTE
NEGROS I.
BOHOL I.
DINAGAT I.
SIARGAO I.
CAMIGUIN I.
MINDANAO
SULU SEA
CELEBES SEA
BORNEO
JOLO I.
TAWI-TAWI I.
Cagayan Sulu I.
CHINA SEA
PHILIPPINE SEA
118°
120°
122°
124°
126°
128°
20°
18°
16°
14°
12°
10°
8°
6°

PLATE 3

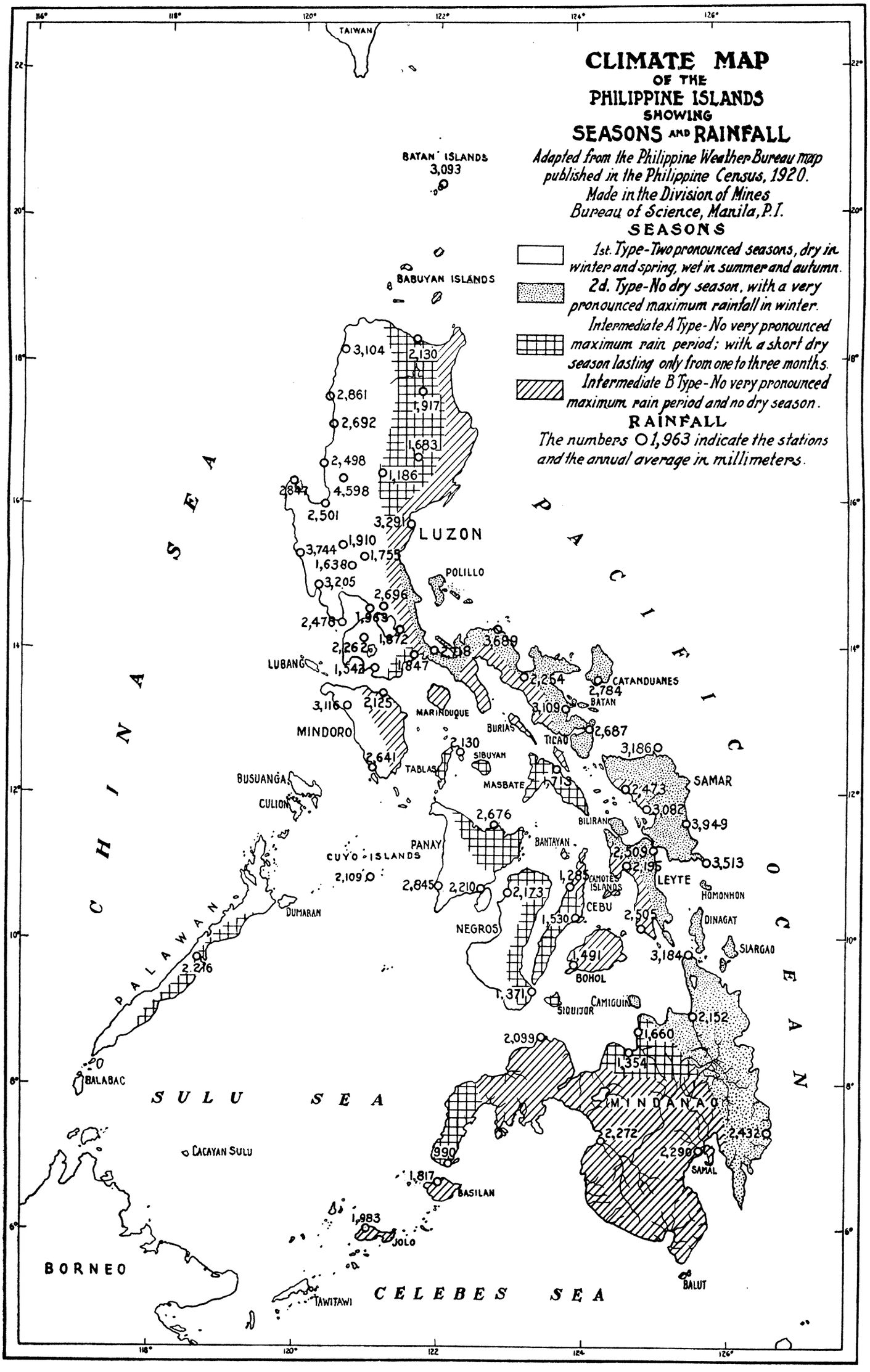

PLATE 4.

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THE GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1924 AND 1925

ISSUED BY THE DIVISION OF GEOLOGY AND MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1927